# Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

April 1956

**The New Stainless Steels—M & M Manual No. 126**

**Metal Powder Show Preview**

Aluminum Powder Metallurgy Products

Large Metal Powder Parts

Developing Design Data for Plastics

Rubber-Modified Alkyd Sealers

Using Quality Control Methods for Materials Selection

Stainless vs Titanium

Complete Contents—page 1

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**APRIL 1956** **VOL. 43, NO. 4**



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**In goes the new Rolock "Neu-pot"**—into one of Eastern Heat Treating and Brazing Company's neutral-salt-bath furnaces. It's made of 1/4" Inconel plate, welded to an Inconel head, flanged and dished by Lukens Steel Co. X-ray inspection insures sound, non-porous welds. For complete data, write Rolock Incorporated, Fairfield, Conn.

# New, wrought Inconel pots give low cost-per-hour neutral-salt operation

## *Rolock's "Neu-Pot" chalks up 3300 hours without sign of failure*

Now, with a new wrought Inconel* nickel-chromium alloy pot, you can expect long, dependable service from neutral-salts bath equipment.

The new unit (called the "Neu-pot" because it's intended for neutral-salt furnaces) was designed and fabricated by Rolock, Inc., Fairfield, Conn.

More than a year ago, one of the first Inconel nickel-chromium alloy units was installed at Eastern Heat Treating & Brazing Corp., New York, N. Y. No sign of failure yet, despite two-shift service at 1525°F. Previously Eastern often replaced pots within four months . . . sometimes within 500 hours. Sometimes sudden failures even ruined furnace linings.

Now, with Inconel, Eastern Heat Treating gets long, *dependable* salt-pot life . . . and a low cost-per-hour operation.

**The INTERNATIONAL NICKEL COMPANY, Inc.**
67 Wall Street New York 5, N. Y.
*Registered trademark


**Want more life from your heat-treating equipment?**

**Here are two suggestions.**
**First, look into Inconel... retains high strength at high temperatures, resists corrosive attack by most heat-treating atmospheres, easily fabricated.**
**Second, send for "Keeping Operating Costs Down When Temperatures Go Up," Inco booklet packed with ideas for improving life and operation of heat-treating equipment, fixtures.**

**Inconel...** *for long life at high temperatures* INCO TRADE MARK **Nickel Alloys**

**For more information, turn to Reader Service Card, Circle No. 440**

# Materials Outlook

MADE FROM SCRAP LEATHER, a new material is said to combine the advantages of natural leather and plastics. The reprocessed leather will sell at half the price of natural leather and two-thirds that of plastics. In addition, the product can be engineered to customer specifications for tensile strength, flexibility, abrasion resistance and stitching characteristics.

TITANIUM SCRAP PROBLEM may be solved by an electro-refining method. Various grades of scrap are fed into an electrolytic cell where the titanium is dissolved and deposited as a pure metal on the cathode. Undesirable impurities are left behind. So far, more than 70% of the metal produced by this experimental method has been premium grade.

UNUSUAL PLASTICS LAMINATE developed for business machine housings is made by laying up glass fabric and polyester resin against a vinyl sheet laminate. Material provides flexibility of design associated with reinforced plastics and retains chemical and visual properties of textured vinyl sheet for outer surface. Vinyl laminate especially developed for this application consists of 20-mil unembossed vinyl sheet coated with 5- or 8-mil layer of vinyl plastisol and fusion bonded to a stretchable, knitted cotton fabric.

TEAR STRENGTH OF PAPER is improved 3½ times and fold endurance 42 times by the addition of 25% nylon to a pulp bonded with nylon resin. Tear strength of 100% nylon paper averages 14 times and fold endurance 75 times that of cellulosic paper bonded with the same resin.

CARBON CONTENT OF STEELS can be analyzed to within 0.0005% by means of new equipment. The technique is used in analysis of steels where accuracy greater than that provided by standard equipment is required, usually for steels in the range below 0.03% carbon.

SOLVENTLESS SILICONE RESINS can now be formulated in any viscosity from that of water to that of a heavy tar. Previously, use of silicone resins has sometimes been limited by their high viscosity. Tested as insulating materials, the new resins have operated up to 10 yr at 390 F and for short periods at over 480 F.

CREEP AND OTHER TIME-DEPENDENT PROPERTY DATA on reinforced plastics is becoming available. More than 12 papers on these subjects were delivered at the recent SPI Reinforced Plastics Div. meeting in Atlantic City. Emphasis was on creep and stress rupture characteristics of glass-thermosetting resin laminates in various environments and at various temperatures. One major problem in interpreting test data is the difficulty in obtaining consistent test specimens.

# Materials Outlook

SHORT-LIFE TITANIUM PARTS may be designed at stress levels well above the metal's endurance limit. Rotary beam fatigue tests show that titanium is pseudo-elastic. The linear stress-strain curve during cyclic loading extends well beyond the linear portion of the stress-strain curve obtained by static tests.

STRONG, LIGHTWEIGHT CONCRETE can be manufactured by introducing a foaming agent and a water soluble plastic into the mix. Result is a homogeneous cellular structure, each cell being coated with high-tensile strength plastic. Density control from 40 to 150 lb per cu ft is possible, and strengths can range from 300 to 3000 psi.

PLASTICS PRODUCTION WILL TRIPLE in this country by 1975 according to one authorty. Today's production of 3.6 billion pounds was achieved in just 15 yr and approximates or exceeds that of materials such as copper, zinc, natural fibers, rubber, aluminum, ceramics and leather.

FLAKE GLASS ADDED TO POLYETHYLENE increases rigidity of the plastic and raises temperature resistance approximately 50 F. It also improves dielectric characteristics of polyesters, epoxies and phenolics. Other uses for the non-uniform flat flakes are in paints and finishes to improve abrasion resistance, and in road-bed materials such as macadam. Anticipated quantity prices for the reinforcing material are 20-30 cents per pound.

MOLDING CYCLE OF REINFORCED PLASTICS may soon approach the production rate of metal stamping. One technique for high speed molding is dielectric heating, i.e., inducing heat by high voltages across the material in the press. Curing times of less than 50 sec have been achieved. Another approach being investigated is the use of thermoplastic instead of thermosetting resins. Glass mat-reinforced polystyrene moldings (40% glass), made on an experimental machine with exceptionally fast heating and cooling cycles, appear to have good properties.

GLASS REINFORCED LEAD AND ZINC are now in the experimental stage. Modulus, elongation and tensile properties are said to be greatly improved in both materials. Radiation shielding looms as an application for the lead-base material. A possible application for the zinc-base material is premixes for die casting-analogous to premix plastics molding compounds. Glass reinforcement of other nonferrous metals is also under investigation.

PLASTICS PRESSURE VESSELS are no longer limited to military applications. One molder has produced a home water softener tank of polyester-glass that weighs just 16¼ lb. It has a minimum burst pressure of 500 psi, and has withstood 200,000 air cycles from 0 to 150 psi at the rate of 6 cycles per min. Wall thickness is 3/16 in.

## Materials BRIEFS

**Rapid Rust**

An indoor corrosion test has been developed which duplicates three years of outdoor exposure in 20 days. Method is used to evaluate experimental alloy steels.

**Tinted Highways**

Residue from the bauxite refining process is being added to asphalt. Roads made with this product will offer durability, reduced glare and a variety of hues, including red, green, white, brown and yellow.

**World Inflation**

Plastics balloon-type world globes are now on the market. When inflated, the globes measure 18 in. in dia and are coated so that crayon marks can be erased.

**Can Openers**

During 1955, Americans opened and used each day an average of approximately 100 million containers (tin and glass) of canned foods of all kinds. Production of cans last year reached 38 billion units.

**Sculptured Plastics**

Latest in sculpture are statues made of reinforced polyester resin. The resin is lightweight, permanent, easily worked and cheaper than bronze.

**Vinyl Markers**

Automobile traffic lanes can be marked with vinyl plastics strips. Applied to the pavement with a special cold adhesive, the strips will not crack or chip under heavy traffic and will not become brittle in cold weather or soft in hot weather.

**Conversation Piece**

Houston has a Plexiglas weather ball on top of one of its skyscrapers. The sphere is 18 ft in dia and changes color to predict the weather.

# Men of Materials...

**John M. Warde,** formerly Head of the Ceramic Laboratory at Oak Ridge, is now with Union Carbide and Carbon Corp. in New York City. Dr. Warde has worked for A. P. Green Fire Brick Co., and for the Vereeniging Brick and Tile Co., Ltd. in the Union of South Africa. During the immediate post-war years, he served as Ceramic Specialist and Production Control Officer for the Ceramic Industry on the staff of the Military Government for Germany.

*Warde says:*

**"A bold new design approach is needed for effective use of high temperature ceramics."**

"Designs involving high temperature ceramics have been mainly attempts to substitute these materials for metals. I feel that before we can successfully solve the problems in the gas turbine, jet engine and nuclear power fields, a complete revision of design concepts is necessary to provide specifically for the use of high temperature ceramics.

"To initiate these design concepts, the designer must be supplied with adequate information on these new materials. A major task confronting the ceramic engineer is to provide a body of engineering data to give the designer the confidence he needs to build his designs around high temperature ceramics.

"Turning to past accomplishments, the ceramic engineer has provided a host of new refractories with new and unusual properties to meet the special demands of defense weapon designers. All of us can see the great advantages that could be gained in gas turbine and jet propulsion engines by the use of these new materials. Of special interest, I think, is the potential application of high temperature ceramics as materials in the construction of compact nuclear reactors of high efficiency which would use gas as the heat transfer medium in producing nuclear power.

"The application of high temperature ceramics in these areas and particularly the designing of components for maximum utilization of these materials will effect a considerable saving in the use of critical metals. Development of strategic items would thus be less dependent upon the availability of metals now in domestic short supply."

*Design Conference*
*Isocyanate Expansion*
*Cyclotron Bolts*
*M&M Market Survey*

## Program Set for ASME Design Engineering Conference in May

Nine authorities representing various aspects of design engineering will lead four days of discussions at the Design Engineering Conference to be held at Convention Hall, Philadelphia, May 14 to 17.

The conference, sponsored by the Machine Design Div. of the American Society of Mechanical Engineers, will be held at the same time and place as the First Design Engineering Show.

For more details on the Design Engineering Show, see special message from the editors, p. 33.

The four editors who acted as a special committee to draft the conference program are: H. R. Clauser, *Materials & Methods;* Colin Carmichael, *Machine Design;* G. F. Nordenholt, *Product Engineering;* and F. C. Oliver, *Electrical Manufacturing.*

**Conference Program**

Monday, May 14

**Value Analysis in Product Design** — A. D. Bentley, Value Analysis Services Sec., and W. L. Healy, Data Bureau, General Electric Co.

Tuesday, May 15

**How to Get and Train Design Engineers**—A panel discussion. Chester Linsky, Industrial Engineering Dept., Pennsylvania State Univ.; A. A. Johnson, Switchgear Div., Westinghouse Electric Corp.; and Bernard J. Covner, Dunlap & Associates, Consultants.

Wednesday, May 16

**Selecting Engineering Materials for Products** — W. A. Irvine,

*(Continued on p. 272)*

**Urethane foams** *Reacting isocyanates with various compounds produces a variety of urethane foams. Versatility of these foams is demonstrated by the end products already on the market.*
*(E. I. du Pont de Nemours and Co., Inc.)*

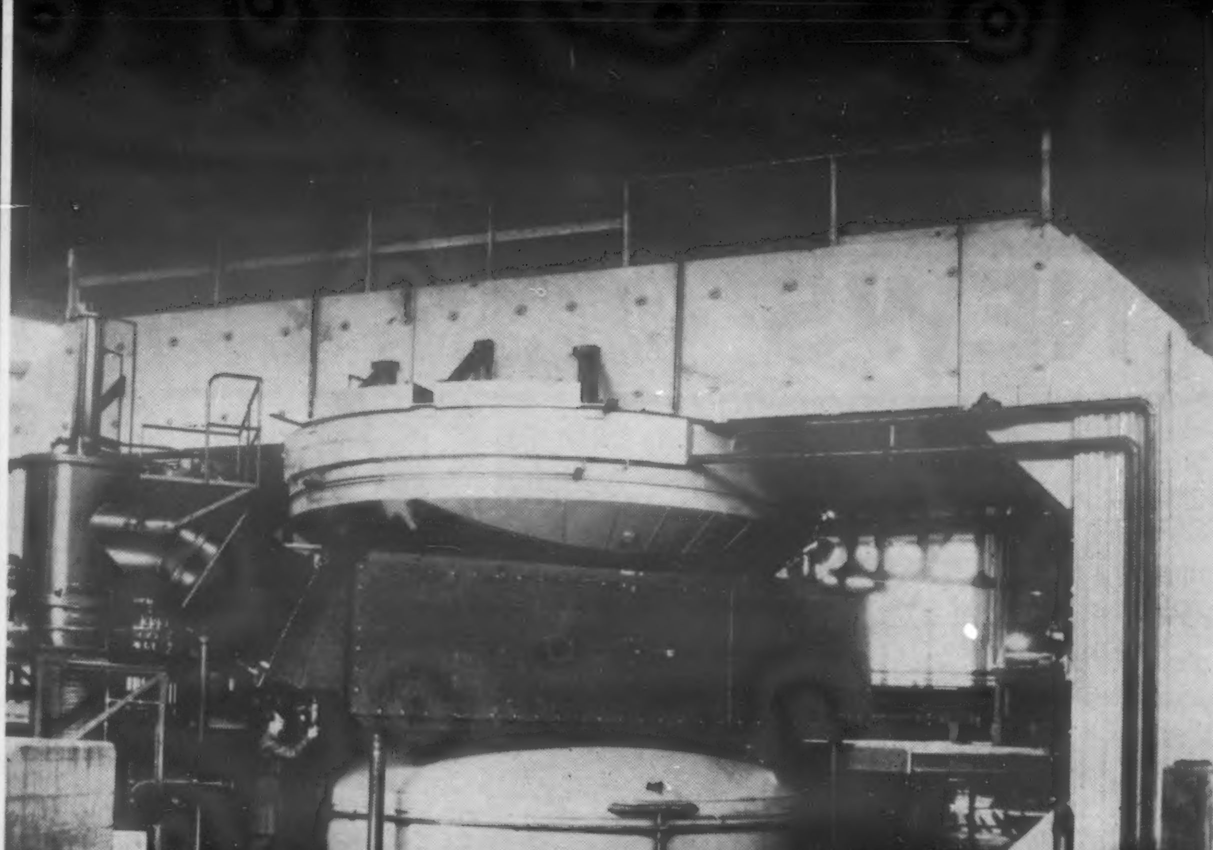
## Isocyanate Production Geared for Growing Urethane Foam Market

From one million lb in 1955 to 10 million lb this year is the optimistic forecast of Du Pont officials regarding the sale of isocyanates. In line with this prediction Du Pont announced the completion of its new isocyanate plant geared to manufacture 25 million lb of these versatile chemicals a year. The plant is located at Du Pont's Chambers Works in Deepwater Point, N. J.

Organic isocyanates, of the types being made at the new plant, combine with other compounds to form rubber-like or plastics-like materials with wide potential use in such fields as building, transportation, upholstery and insulation. By reacting polyisocyanates with alkyd resins, alcohol, amines or even water, chemists have developed many radically new materials, ranging from rigid and flexible foams to a new experimental synthetic rubber for automobile tires. *(See M&M, Aug. 1955, pp. 84-88.)*

With a multitude of potential uses in sight for these urethane foams, other companies are vying for a share of the isocyanate market. New plants scheduled for production this year include those of Mobay Chemical Co. in New Martinsville, W. Va., and National Aniline in Moundville, W. Va.

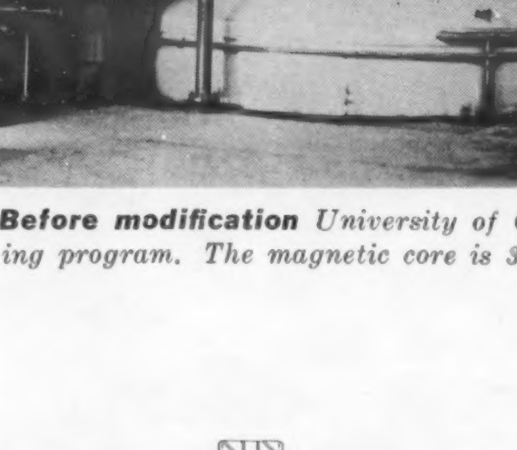
# Giant Steel Bolts Keep Cyclotron from Flying Apart



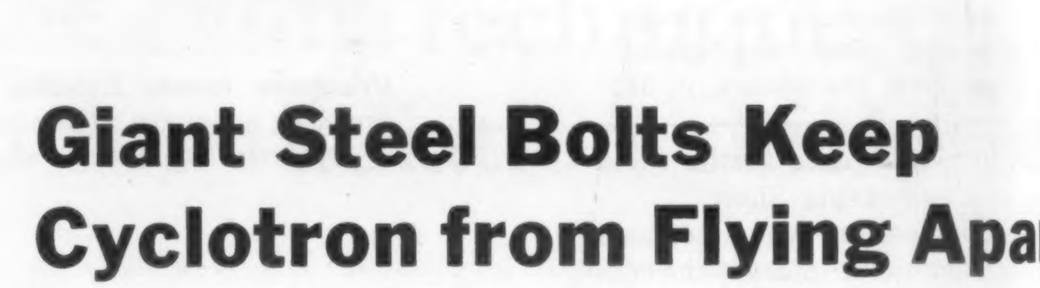
**Before modification** *University of California cyclotron before the rebuilding program. The magnetic core is 30 ft high, 56 ft long and 15½ ft wide.*

■ High strength alloy steel bolts, 15 ft long by 3.5 in. dia, will be used in rebuilding the University of California cyclotron. Made of 4340 nickel-chromium-molybdenum steel, the bolts will be heat treated to a yield strength of 100,000 psi or a total strength of 1 million lb per bolt.

Big reason for these high strength levels is the uncertainty inherent in measuring the magnetic forces generated when the 730 million electron volt cyclotron is energized. These magnetic forces are expected to measure up to 1000 tons, but model tests have shown an added complication. When the cyclotron is energized the steel plates which make up the 184-in. dia poles will be in a state of unstable equilibrium. If the plates should start to separate, the




**Preloading bolt** *Hydraulic jack on yoke end of bolt applies tension of approximately 230 tons through the load transfer sleeve, stretching the bolt about 3/8 in.*




**Cyclotron diagram** *Six of the 26 prestressed bolts in the 730-Mev proton cyclotron are shown in this sketch. There are 19 bolts in the upper pole and yoke and seven in the lower pole and yoke.*

magnetic forces would be magnified and cause the plates to separate farther, i.e., they would tend to fly apart.

Maximum load on each of the 26 bolts supporting the pole bases is expected to reach approximately 350,000 lb. This necessitates preloading of the bolts during installation to approximately 450,000 lb so that the maximum expected load will not exceed the preload during cyclotron operation. In this way the bolts will not be stressed further by magnetic forces.

#### Preloading operation

In the preloading process the bolts will be stretched about 3/8 in. Strains of this magnitude, if caused by magnetic forces, would separate the plates enough to cause disastrous results.

Preloading the bolts will be done with a specially designed hydraulic jack. This jack has a capacity of 300 tons and is made with a central hole through the piston so that force can be transmitted to the bolts. The nuts can then be hand tightened until they are seated. Sleeve openings permit use of a spanner wrench to tighten the nut further. The jack will be supported by a sleeve that surrounds the bolt end, the nut and the load cell used to measure bolt loads.

#### Measuring bolt loads

A method for measuring bolt loads developed by Baldwin-Lima-Hamilton Corp. permits easy access to, and replacement or recalibration of, the load-sensing element without removing the bolt. The load-sensing element is simply a ring on which SR-4 resistance wire strain gages are bonded. These load cells are only 6 in. dia and 6 in. long but have a capacity of one million pounds. In addition they have extremely small deflection under load and a high sensitivity.

Modification of the cyclotron began last September and will require six to nine months for completion. Replacement of the pole bolts and installation of the load cells is a major phase of this extensive project.

# M&M Market Survey of Fibrous Materials

Among M&M readers, fibrous materials are most widely used for insulation purposes, and the most widely used fibrous material is felt.

These facts were disclosed by a recent M&M survey of markets for fabrics, industrial fibers and other fibrous materials. The tables below show percentages of plants using various types of fibrous materials and percentages of plants using fibrous materials for various purposes.

| MATERIALS | |
|---|---|
| Felts | 57 |
| Woven fabrics | 42 |
| Coated fabrics | 40 |
| Yarn, cord or cable | 28 |
| Nonwoven fabrics | 28 |
| Staple or filament fiber | 25 |
| Roving | 5 |
| Knit fabrics | 5 |
| Linters | 3 |

| USES | |
|---|---|
| Insulation (thermal, acoustic, electrical) | 76 |
| Padding and packaging | 32 |
| Plastics reinforcement | 31 |
| Fiberboard or vulcanized fiber | 19 |
| Rubber reinforcement | 15 |
| Dry filtration | 12 |
| Upholstery and seating | 12 |
| Wet filtration | 9 |

# Plan Suggested for Cooperative Materials Approval

Formation of a nonprofit qualifying agency to furnish tests for materials acceptable to both consumer and producer was recently proposed by Charles M. Miller of Northrop Aircraft, Inc.

Mr. Miller suggested an industry supported nonprofit organization which would draw up lists of approved materials and their specifications based on data supplied by independent laboratories. In addition to the materials in general usage, this would also include the newer materials such as metallic molybdenum, titanium alloys, ceramic, powder metal materials, new elastomers for high temperature hydraulic fluid packing applications, heat resistant transparent materials and radiation altered materials.

The burden of approval, Miller states, rests at this time with the user. At present each company establishes its own rules for qualification. This may vary from superficial examination to rigid testing to all specification requirements. Thus, the supplier faces the staggering task of proving to each of many users that his product meets or exceeds specifications.

Some benefits listed in the Miller plan are:

1. Provision of a basis for buying or selling by publishing lists of qualified products.
2. Assurance to the ultimate consumer of greater safety in use of the end product.
3. Reduction of costly delays schedule-wise by providing approved product lists in advance of need.
4. Release of technical staffs of both producer and user from routine qualification testing, and provision of a test facility available to those who have no technical staffs.
5. Elimination of duplicated effort. The producer would not need to supply quantities of material for testing to prospective users, and buyers would be relieved of technical responsibilities.

Because of the interest aroused by this proposal, the Society of Automotive Engineers is currently circulating a questionnaire to industry to determine its feasibility.

*(More News on p. 272)*

# LETTERS TO THE EDITOR

### *Hot dip galvanizing*

*Certain misstatements in our brief discussion of hot dip coatings which appeared in the September Manual, "Finishes for Metal Products," have been brought to our attention by the American Hot Dip Galvanizers Assn., Inc.—in particular, an overemphasis on the non-uniformity of hot dip coatings, and an error in giving the range of thickness of such coatings. Following are excerpts from the letter written by Stuart J. Swensson, Secretary of the Association:*

To the Editor:

While we feel Manual No. 119—"Finishes for Metal Products"—is an excellent overall treatment of the subject, we are quite disappointed in the brief and somewhat uncomplimentary references to "hot dip coatings", particularly hot dip galvanizing, as set forth on page 128 thereof.

Zinc coatings by the hot dip galvanizing process have been duly recognized over a period of years as the best commercial rust-resisting coating, particularly outside atmospheres. To state "except on simple shapes, however, hot dip coatings are exceedingly non-uniform and wasteful of material" is, to say the least, inaccurate . . .

Generally speaking zinc coatings by the hot dip galvanizing process are relatively uniform as to weight or thickness. A small degree of non-uniformity could, depending on the manner of withdrawing which is influenced by the size, shape and weight of the article from the bath, occur at that stage of the process by a minor drainage from the top toward the bottom of the article . . .

Under good commercial practice iron and steel products being hot dip galvanized take on their natural gain in weight which for the most articles averages 2 oz or more per sq ft of surface. As it is duly recognized that the thicker or heavier the coating, the longer the life of protection against corrosion, it is not accurate to state that this is a "waste of material", if the best protection against corrosion is desired . . .

. . . you . . . admit that the range of thickness mentioned in the Manual is too low and that it might well have been stated—"1.8 to 3 mil or more". In our opinion this is still much too low in expressing the weight or thickness of coating. . . . According to the ASTM 1 oz equals .0017 in. or 1.7 mil.

The "natural gain in weight" by the commercial hot dip galvanizing process is approximately 2 oz per sq ft of surface or 3.4 mil. Therefore, unless some mechanical means were employed to reduce this natural gain in weight any commercial hot dip galvanized coating as "low" as 1.8 mil per sq ft of surface would be far below that normally produced and lower than the minimum weight of coating in any ASTM specification now covering hot dip galvanizing . . .

Zinc coatings by the hot dip galvanizing process is one of the oldest methods of protecting iron and steel products from corrosion. Theoretically as well

*(Continued on p. 286)*

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**This card not good after June 1.**

## TRADE SHOWS

**DESIGN ENGINEERING SHOW.** Clapp & Poliak, Inc. Literature, for both visitors and exhibitors, describing the Design Engineering Show—to be held in Philadelphia, May 14 to 17—as well as free admission tickets for visitors. (1)

**PLASTICS SHOW & CONFERENCE.** Society of the Plastics Industry, Inc. Literature describing National Plastics Exposition and concurrent Plastics Industry Conference—to be held in New York City, June 11 to 15. (2)

**Stainless Steel.** Allegheny Ludlum Steel Corp. Data Sheet on stainless steel Type 301, an austenitic steel with a nominal composition of 17% Cr and 7% Ni. (3)

# MANUFACTURERS' LITERATURE

## New Literature

**Brazing Aluminum.** Aluminum Co. of America, 744 Alcoa Bldg, Pittsburgh 19, Pa., 134 pp., illus. Describes brazing materials for aluminum and details the considerations involved in designing, preparing and assembling brazed joints. Write direct to Alcoa on company letterhead.

**Carbonyl Iron Powder.** Antara Chemicals, Div. of General Aniline & Film Corp., 8 pp. Data on the ten types of GA&F carbonyl iron powder. Includes graphs on properties. (5)

**Molybdenum Silicides.** Climax Molybdenum Co., 8 pp, No. Cdb-6. Information on molybdenum silicides consolidated from 52 reference sources. Includes properties and multisilicide system diagrams. (6)

**Epoxy Adhesives.** Furane Plastics Inc., 1 p. Brochure on epoxy adhesives for application in metal, plastic and ceramic bonding. (7)

**Powder Metallurgy Handbook.** International Powder Metallurgy Co., Inc., 28 pp. Concise engineering data on all aspects of the powder metallurgy process. (8)

**Glass Fibers.** L. O. F. Glass Fibers Co., 8 pp, illus, No. WPD-11. Illustrates application of glass fiber products in reinforced plastics and in yarns for the textile industry. (9)

**Steel.** Lukens Steel Co., 24 pp, illus. Engineering and design data on Lukens T-1, a high strength, readily welded, weight saving alloy steel. (10)

**Foamed Plastic.** Nopco Chemical Co. Suggested applications of Nopcofoam, a flexible foamed plastic. (11)

**Titanium.** Rem-Cru Titanium Inc., 12 pp. Data sheet on Rem-Cru C-130AM. (12)

**Men and Steel.** American Iron & Steel Institute, 8 pp, illus. An explanation on the making and uses of steel for grade school children. (13)

**Resistance Welding.** Ampco Metal, Inc., 4 pp, illus. Describes and illustrates company facilities for producing resistance welding electrodes and alloys. (14)

**Plastic Finish.** John L. Armitage & Co., 8 pp. Information on Armorhide, a textured plastic finish resembling leather. (15)

**Metal Polishing.** Coated Abrasives Div., Armor & Co., 8 pp, illus. Discusses the advantages of using the coated abrasive belt-backstand idler method of metal polishing. (16)

**Mechanical Tubing.** Tubular Products Div., The Babcock & Wilcox Co., 4 pp, illus, No. TB-360. Describes alloy steel mechanical tubing for use in part fabrication. (17)

**Beryllium Copper Dies.** The Beryllium Corp., 4 pp, illus. Covers use of beryllium copper dies for plastics, steel, titanium and zinc. (18)

**Magnesium-Thorium Alloy.** Brooks & Perkins, Inc., 28 pp. Gives data for designers on new temperature resisting

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magnesium alloy, HK-31. Includes graphs and charts. (19)

**Fiber Pipe.** The Central Foundry Co. Catalog of specifications for bituminized fiber sewer pipe, perforated pipe and couplings. (20)

**Thermal Conducting Cement.** Chemax Mfg. Corp., 10 pp, illus. Describes use of thermal conducting cements to improve heat transfer between tracing and process equipment. (21)

**Metal Cleaning.** Circo Equipment Co., 4 pp, illus, No. OP2. Vapor spray degreaser which can be used with gas, electric or steam heating systems. (22)

**Metal Laminate.** Columbus Coated Fabrics Corp., 12 pp, illus. Describes Col-O-Vin, a semi-rigid vinyl sheeting which can be bonded to steel or nonferrous metals. Samples included. (23)

**Aluminum Surface Treatment.** Conversion Chemical Corp., Fact Sheet F-1. Describes chrome sealer films for treating aluminum. Film increases electrical properties of aluminum and also forms a good base for painting. (24)

**Finish for Glass Cloth.** Dow Corning Corp., 2 pp, No. 8-405. Data on water dilutable silicone finish for glass cloth. Can be used with epoxy, phenolic, polyester and silicone resins. (25)

**Vinyl Foam.** Elastomer Chemical Corp., 14 pp, illus. Characteristics and uses of vinyl foam discussed in terms of successful applications. (26)

**Shell Mold Castings.** Electric Steel Foundry Co., 12 pp, illus, No. 205. Describes advantages of shell mold castings and illustrates castings made for various industries. (27)

**Industrial Tape.** Industrial Tape Div., Seamless Rubber Co., 60 pp, illus. Industrial tape catalog lists properties and pictures various types of tape. Includes breakdown of tape use in specific industries. (28)

**Resin Coatings.** Chemical Div., General Mills, Inc., 8 pp, No. 11-4-3. Data on polyamide resin-epoxy thermoset compositions and their use as paper coating and laminating materials. (29)

**Electrical Contacts.** Gibson Electric Co., No. C-520. Technical data on contacts and contact assemblies to fit the needs of an electrical or electronic product. (30)

**Vacuum Furnaces.** High Vacuum Equipment Corp., 8 pp, illus, No. 552. Describes furnaces and equipment for vacuum annealing, heat treating and brazing. (31)

**Electron Beam Processing.** High Voltage Engineering Corp., 32 pp, illus, No. E. Gives data on high voltage electron beam processing. Use possibilities include cross-linking of plastics and the initiation of polymerization. (32)

**Pressure Nitriding.** The A. F. Holden Co., 8 pp. Describes liquid pressure nitriding process for use on certain classes of steels. (33)

**Injection Molding Machines.** The Hydraulic Press Mfg. Co., No 5601. Gives specifications on new molding machines and shows plastics ware being designed and produced. (34)

**Magnet Materials.** The Indiana Steel Products Co., 12 pp, illus, No. 5-R. Guide to permanent magnet materials and their selection. Includes chart summarizing physical data and design factors. (35)

**Hardness Conversion Tables.** International Nickel Co., Inc. Celluloid card, 2¾ x 4¾ in., gives approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steels. (36)

**Aluminum Extrusions.** Kaiser Aluminum & Chemical Sales Corp., 24 pp, illus. Information on two new 8000-ton extrusion presses. Includes extrusion design suggestions. (37)

**Ceramic Mold Casting.** Lebanon Steel Foundry, 4 pp, illus. Process for producing close tolerance steel castings from ceramic molds. (38)

**Metal Alloy Products.** Little Falls Alloys, Inc., 2 pp, illus. Describes copper, titanium, aluminum and nickel alloys available and the use of these alloys in various products. (39)

**Barrel Finishing.** Lord Chemical Corp., 40 pp, illus. Handbook on the precision barrel finishing of metals, metal alloys and plastics. (40)

**Plastics Tools.** Marblette Corp., 6 pp, illus. Bulletin explains advantages of plastics tools in foundry use. (41)

**Wood Products.** Masonite Corp., 12 pp, illus. Guide to Presdwood products. Tabulates properties, available sizes, and describes working and finishing methods. (42)

**Soldering.** McDowell Electronics Inc., 4 pp, No. 561. Describes equipment for soft soldering of metallized ceramic and glass, hot tin dipped brass, copper, silver and steel. (43)

**Surface Measurements.** Micrometrical Mfg. Co., 2 pp, illus. Illustrates equipment for measuring surface roughness. (44)

**Bearing Bronzes.** Mueller Brass Co., 22 pp, illus. Describes forgeable bearing bronzes. Includes physical and design data. (45)

**Pipe Fittings.** Naylor Pipe Co., 4 pp, illus, No. 525. Illustrates fittings for lightweight metal pipe. (46)

**Molding Compounds.** Plumb Chemical Corp., 6 pp, illus. Data sheets on Fibercore molding compounds. Includes product applications and price lists. (47)

**Inert Gas Welding.** Pure Carbonic Co., Div. of Air Reduction Co., 4 pp, illus. $CO_2$ supply systems for inert gas welding requirements. (48)

**Barrel Finishing.** Rampe Mfg. Co., 2 pp, illus. Specifications on precision barrel finishing machine. (49)

**Powdered Metal Parts.** Reese Metal Products Corp., 1 p, illus. Tells how costs are cut through use of powdered metal parts. Also lists physical characteristics of selected powdered metals. (50)

**Steelmaking.** Rotary Electric Steel Co., 12 pp, illus. Color photographs illustrate the various steps in the steelmaking process. (51)

**O-Ring Sizes.** Rubber Products Div., Parker Appliance Co., 12 pp, No. 5701. Lists 296 Standard O-ring sizes for sealing applications. Includes cross reference charts of size numbers with dimensional data. (52)

**Plastics Molding.** Shaw Insulator Co., 12 pp, illus. Details facilities for custom molding of plastics. (53)

**Miniaturization.** Standard Pressed Steel Co., 20 pp, illus. Describes application of miniaturization to industrial and product design. Charts and photographs illustrate basic principles of technique. (54)

**Stainless Strip.** Superior Steel Corp., 32 pp, illus. Technical information on 20 types of stainless strip steel. Includes table on weight per lineal foot of strip steel for various thicknesses and widths. (55)

**Chromium Finished Aluminum.** Tiarco Corp., 2 pp, illus. Explains Hardalume process for providing a surface layer of hard chromium on aluminum. (56)

**Sintered Bearing Alloys.** U. S. Graphite Co., Div. of Wickes Corp., 6 pp, illus, No. 18. Discusses design and metallurgical requirements for selection of sintered metal bearings. (57)

**Tap Guide.** The Wood & Spencer Co. Tap guide wall chart with 12 reference tables. Table includes tapping speeds, decimal equivalents, and tap terminology. (58)

**Metalworking Presses.** R. D. Wood Co., 4 pp, illus. Illustrates hydraulic presses for bending, cogging, flanging, forging, forming, straightening, and upsetting operations. (59)

**Metal Stamping.** Worcester Pressed Steel Co., 8 pp, illus. Company facilities for custom metal stamping. (60)

**Cold Finished Steels.** Wyckoff Steel Co., 87 pp. Handbook gives basic engineering data on cold finished steels. Includes numerous tables of properties and specifications. (61)

# Other Available Literature

## Irons and Steels • Parts • Forms

**Steel Weldments vs. Castings.** Acme Tank & Welding Div., United Tool & Die Co., 20 pp, illus. Booklet furnishes basic facts about steel plate fabrication as compared to casting for manufacturers and designers of heavy machinery, equipment, service apparatus and components. (63)

**Screw Machine Parts.** Allmetal Screw Products Co., Inc., 96 pp, ill, No. 53. Catalog of bolts, nuts, keys, valves and fittings and other screw machine products. Thumb indexed. (224)

**Stainless Steel Powders.** Alloy Metal Powders, Inc. Concerns sintering of high temperature alloy powders in the stainless steel group and the availability of such grades. (64)

**Weldments.** American Welding & Mfg. Co., 23 pp, illus. Describes company's welding facilities, including list of products and specific services available. (227)

**Low-Alloy Steel.** Bethlehem Steel Co., 66 pp, illus, No. 353. Properties and features of Mayari-R steel for use in applications requiring high strength and good wear and corrosion resistance. (65)

**Stainless Steel Tubing.** J. Bishop & Co., Platinum Works, 7 pp. Mechanical, capillary, hypodermic, and small tubular specialties in stainless steel, nickel, and nickel alloys. Table of comparative properties of various alloys. (66)

**Heating Rate of Steel.** Bloom Engineering Co., 30 pp, illus. Reprint of AISI paper, "The Rate of Heat Absorption of Steel", detailing a simplified method to calculate steel heating rates and center temperatures. (67)

**Iron and Steel Castings.** Campbell, Wyant & Cannon Foundry Co., 24 pp, illus. Describes types of gray iron and steel castings. (68)

**Alloy Comparison Chart.** Cannon-Muskegon Co. Comparison chart of AISI, SEA, ACI, AMS, WAD, PWA alloy specifications. (69)

**Stainless Tubing and Pipe.** Alloy Tube Div., Carpenter Steel Co., 4 pp, illus. Describes corrosion and oxidation resistant steel tubing. Outlines uses and gives size range of tubing and pipe available. (70)

**Forgings.** Cleveland Hardware & Forging Co., 38 pp, ill, No. 19A. Catalog of stock industrial and automotive forgings. (234)

**Weldments.** The Cleveland Welding Co. Illustrated brochure describes special process of radial welding of circular steel parts. (236)

**Lead Treated Steels.** Copperweld Steel Co., 8 pp, illus. Discusses lead addition to steel and its effect on machinability. (72)

**Stainless Steel Fabrication.** Crucible Steel Co. of America, 160 pp. Fabricator's handbook for Rezistal stainless steels. Forming, machining, cutting, joining, heat treating, pickling, finishing and reference data. (73)

**Stainless Steel Tubing and Pipe.** Damascus Tube Co., 8 pp, illus. Profusely illustrates the manufacturing process of stainless steel tubing and pipe offered by Damascus. (74)

**Custom Steel Parts.** Henry Disston Div., H. K. Porter Co., Inc., 16 pp, illus. Describes custom steel parts, how they are made and how to use and order them. (75)

**Powder Metal Parts.** Dixon Sintaloy, Inc., 4 pp, illus. Describes facilities for producing powder metal parts. (76)

**Forging Guide.** Drop Forging Association, 6 pp, illus. Management guide to the use of forgings. (77)

**Iron Powder.** Easton Metal Powder Co., Inc., 5 pp, illus. Specifications for designing for Ferroflame "A" iron powder. (78)

**Electrolytic Iron Powder.** A. Johnson & Co., Inc., 30 pp, illus. Detailed account of a high purity powder with higher sintering activity, better compressibility, and a higher flow rate. Made in Sweden. (79)

**Stainless Steel Castings.** Kolcast Industries, Inc., 4 pp, illus. Large stainless steel precision castings made by the frozen mercury process. (80)

**Welded Assemblies.** The R. C. Mahon Co., 1 p, illus. Shows several examples illustrating the capabilities of welding for construction of various assemblies. (258)

**Malleable Iron.** Malleable Founders' Society, 4 pp, illus, No. 52. New facts on the uses of malleable iron are given. (81)

**Carbon and Alloy Steel Tubing.** Ohio Seamless Tube Div., Copperweld Steel Co., 8 pp. Describes four major classifications of carbon and alloy steel tubing; mechanical, pressure, airframe, and aircraft mechanical. Covers both seamless and electric resistance welded tubing, as well as tube fabricating and forging. (278)

**Screw Machine Products.** National Screw Machine Products Assn., 18 pp, illus. Guide to selecting proper screw machine products. Includes discussion of design, burring, heat treating and grinding. (262)

**Formed Wire Products.** Peerless Wire Goods Co., Inc., 8 pp, illus. Facilities and services of company described in manufacture of wire products. (269)

**Powder Metals.** Plastic Metals, Div. of National-U. S. Radiator Corp., 12 pp, illus, No. 2. Covers the production of iron powders as well as nonferrous and alloy powders with suggestions for the utilization of metal powders. (82)

**Iron Powder.** Pyron Corp., 8 pp, No. 1. Technical data sheets on hydrogen reduced and electrolytic iron powders. Sintering data, effect of infiltrants, dimensional stability, strengths, etc., chartered. (83)

**Preformed Metal.** Rigidized Metals Corp., Pattern selector guide for preformed metals. (279)

**Steel Tubing.** Rochester Products Div., General Motors, 12 pp, illus, No. 271. Features typical applications of GM tubing made in both single and double walls of steel. (84)

**Leaded Carbon Alloy Steel.** Joseph T. Ryerson & Son, Inc., 4 pp, illus. Describes fast machining leaded alloy steel supplied in both annealed and quenched-and-tempered condition. (85)

**Steel Tubing.** Summerill Tubing Co., Div. Columbia Steel and Shafting Co., 8 pp, illus. Cold drawn steel tubing for hydraulic applications. (86)

**To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 69 and 70**

**Steel Tubing.** Superior Tube Co., 4 pp, Working data for SAE hydraulic quality low carbon steel tubing. (87)

**Bi-Metallic Construction.** Arthur Tickle Engineering Works, 8 pp, illus. Description of Alumibond process for molecularly bonding aluminum and its alloys to iron and steel and their alloys. (88)

**Stainless and High Alloy Tubing.** Trent Tube Co., 48 pp, illus. Classifies types of tubing, giving typical applications, physical, chemical and electrical properties for each. Information on welding, bending and installation techniques. (89)

**Vacuum Melted Alloys.** Utica Metals Div., Utica Drop Forge & Tool Corp., 8 pp, illus. Describes facilities for producing and testing vacuum melted alloys. (90)

**Die Steels for Cold Work.** Vanadium-Alloys Steel Co., 22 pp, illus. Details, uses, composition and heat treatment of die steels for cold work. (91)

**Steel Strip.** Weirton Steel Co., 20 pp, illus. Characteristics of electrolytic zinc-coated sheets and strip high-tensile steel and high carbon strip cold-rolled spring steel being manufactured by the company. (92)

**Magnetic Alloys.** Westinghouse Electric Corp., Industrial Heating Dept., 8 pp, No. TD-52-100. Complete data on a variety of magnetic alloys produced by this company includes applications and 15 core loss and magnetization curves. (93)

## Nonferrous Metals • Parts • Forms

**Engineering Bronzes.** American Crucible Products Co., 12 pp, illus. Includes complete data on facilities, technical information, case histories and applications of Promet bronzes. (95)

**Bronze Casting Alloys.** American Manganese Bronze Co., 50 pp, illus. Revised edition gives composition, characteristics and applications of the principal copper alloys used to make castings. (96)

**Electrolytic Copper Powders.** American Metal Co., Ltd., 3 pp. Data sheets on specifications for electrolytic copper powders. (97)

**Pre-Finished Metals.** American Nickeloid Co., 24 pp, illus. Fabrication techniques, uses and properties of prefinished metals are described, along with case histories of applications in various manufacturing fields. (98)

**Vacuum Die Casting.** Aurora Metal Co., 8 pp, illus. Describes process for aluminum bronze and silicon bronze. Applications, physical and chemical specifications. (99)

**Aluminum Alloy Castings.** Morris Bean & Co., 4 pp, illus. Description, history, advantages limitations and pattern making facilities for the Antioch process aluminum alloy castings that meet exacting fluid flow specifications. (100)

**Sintered Bronze.** Bunting Brass & Bronze Co., 12 pp, illus, P. 56. Information on stock bearings, flange stock bearings, washers and bars made of sintered bronze. (101)

**Phosnic Bronze.** Chase Brass & Copper Co. Bronze alloy for jobs requiring high-strength metal with good conductivity. (102)

**Metal Powders.** Coast Metals, Inc., 4 pp, illus. Nickel-base alloys in powder form for hardsurfacing and brazing. (71)

**Metal Stampings.** Crosby Co., 40 pp, illus. Describes company's range of facilities for metal stamping. (103)

**Die Castings.** Dollin Corp., 16 pp, illus. Booklet describes plant and facilities for die castings. (104)

**Rings.** Dresser Mfg. Div., Dresser Industries, Inc., 4 pp, illus. Heavy industrial equipment fabrication from welded rings. (105)

**Titanium.** E. I. duPont de Nemours & Co., Inc., Pigments Dept., 8 pp, illus. Up-to-date data on properties of titanium and methods of fabricating the metal. (106)

**High Density Metal.** Fansteel Metallurgical Corp., 16 pp, illus. Properties and uses of Fansteel 77 Metal, machinable tungsten-copper-nickel alloy, 50% heavier than lead, used for counterweights, flywheels, vibration damping, and radiation shielding devices. (107)

**Aluminum Alloy.** Frontier Bronze Corp., 24 pp, illus. Describes Alloy "40-E", a high strength alloy containing zinc with magnesium, titanium and chromium, which needs no heat treatment. Separate data sheets on specifications, composition and properties. (108)

**Thermostat Metal.** General Plate Div., Metals & Controls Corp. Information on selecting thermal elements and their design. Tables give major mechanical and physical constants for various thermostatic metals. (109)

**Metal Powders.** The Glidden Co., 6 pp, Contains specification sheet for lead and Resistox copper powders. (110)

**Lead-Based Babbitt.** Graphitized Alloys Corp., 4 pp. Graphite-containing, lead-base babbitt metal as a substitute for high-tin based babbitt metals. (111)

**Perforated Materials.** Harrington & King Perforating Co., 8 pp, illus, No. 62. A handy thumb index catalog illustrating different standard patterns and giving information on hole size, centers and percent of open area. (247)

**Aluminum Forgings.** Harvey Aluminum Div., 12 pp, illus. Describes aluminum press forgings, impact extrusions, and hand forgings. Outlines mechanical properties of aluminum forging alloys and summarizes typical forging applications. (112)

**Investment Castings.** Hitchiner Mfg. Co., 12 pp, illus. Description of precision investment castings and its advantages and limitations. (113)

**Die Castings.** The Hoover Co., 12 pp, illus, No. 853. Shows this company's facilities for producing zinc and aluminum die castings. Includes design helps, describes applications. (114)

**Tube Fittings.** Imperial Brass Mfg. Co., 4 pp, illus. Tube fittings for use with stainless steel, nylon, polyethylene, aluminum, copper, and other tubing. (251)

**Beryllium Copper Springs.** Instrument Specialties Co., Inc., 16 pp, illus, No. 9. Catalog of company's stock of compression springs, flat springs, strip springs, contact strips and contact rings. (280)

**Centrifugal Castings.** Janney Cylinder Co., 8 pp, illus. Company facilities for centrifugal casting of special alloys. (115)

**Bronze Bars.** Johnson Bronze Co., 4 pp, illus. Completely machined 13-in. bars for bearings, bushings, thrust plates and washers. Other applications and machining data listed. (116)

**Sheet and Plate Fabrication.** Kirk & Blum Mfg. Co., 38 pp, illus. Describes facilities and equipment used in production of metal sheet and plate. (117)

**Rare Earths.** Lindsay Chemical Co., 12 pp, illus. Describes company's work in the rare earth field. (118)

**Tin.** The Malayan Tin Bureau. "Tin News," a monthly publication of the Malayan Tin Bureau, reviews market situation, tin uses and political developments affecting the supply of tin. (281)

**New Titanium Alloy.** Mallory-Sharon Titanium Corp., 4 pp. Properties of MST 6AL-4V, a high stability titanium alloy for use at temperatures to 750 F. Includes heat treating data and stability test results. (119)

**Zirconium.** Metal Hydrides, Inc., 2 pp No. 700-C. Physical properties and handling instructions for zirconium metal, hydride, and powder. (282)

**Metal Powder Parts.** Metal Powder Products, Inc., 4 pp, illus. Features a variety of applications for iron, iron-copper and bronze sinterings made by this company. (120)

**Die Castings.** Monarch Aluminum Mfg. Co. File data on aluminum and zinc die castings and aluminum mold castings showing applications, advantages and this company's facilities for making them. (121)

**Aluminum Core.** Narmco Metlbond Co., 6 pp. Formable core material for aluminum sandwich constructions where application requires small radius curves. (122)

**Cored Forgings.** National Cored Forgings Co., Inc., 8 pp. illus. Advantages and typical examples of cored forgings made of brass, bronze, copper and other nonferrous metals. (123)

**Powdered Metal Bearings.** National Molded Products, Inc., 60 pp. illus. Describes process, design factors and specifications for cylindrical and flanged bearings. Stock list. (124)

**Precision Investment Casting.** National Precision Casting Corp., 4 pp. illus. Case histories of savings effected by using investment casting for small or intricate parts. (125)

**Precious Metal Wire.** The J. M. Ney Co., 2 pp. Technical data on advantages of using Ney-Oro 6, precious metal wire for pivots in instrument bearings. (126)

**Precision Castings.** Ohio Precision Castings Inc., 12 pp, illus. Numerous examples of industrial applications of this company's brass, bronze, aluminum and beryllium-copper plaster mold castings. (128)

**Small Zinc Die Castings.** Page & Hall Mfg. Co., Inc., 4 pp, ill. Zinc die casting process which reduces tool and part cost. Includes brief design guide. (129)

**Die Castings.** Parker White Metal Co. Engineering data on die cast component parts. (130)

**Aluminum Castings.** The Permold Co., ill. Shows how continuous scientific control of Permold aluminum casting quality, to specifications, saves time and money. (131)

**Aluminum Extrusions.** Precision Extrusions, 12 pp, ill. Describes aluminum extrusion process with tables of physical properties and recommended applications. (132)

**Investment Casting Alloys.** Precision Metalsmiths, Inc. Chart covers stainless, low alloy and tool steels, nickel alloys, copper-base alloys and aluminum alloys. Complete chemical analysis and mechanical properties given. Chart rates alloys as to castability, machinability, corrosion resistance, etc. (133)

**Bushings.** Randall Graphite Bearings, Inc., 12 pp, ill, No. 100. Complete price list of bronze bushings and specially grooved bushings; specifications of bored and solid bronze bars. (134)

**Aluminum Products.** Revere Copper & Brass, Inc., 35 pp, illus. Lists products and applications and includes tables on alloys available. (283)

**Nonferrous Alloys.** Riverside Metal Co. A reference and guide to alloy specifications of phosphor bronze, nickel silver, cupro nickel and beryllium copper. (135)

**Spun and Formed Shapes.** Roland Teiner Co., Inc., 5 pp. Hydroforming and spinforming of fabrications of all sizes. (272)

**Roll Formed Shapes.** Roll Formed Products Co., 26 pp, illus. Shows simple and complex sections being produced from both ferrous and nonferrous metals. (273)

**Aluminum and Magnesium Casting.** Rolle Mfg. Co., 58 pp, illus. Guide to design and specifications of aluminum and magnesium, sand, permanent mold and die castings. Discusses advantages and disadvantages of casting methods and gives properties of common aluminum magnesium casting alloys. (136)

**Centrifugal Castings.** Sandusky Foundry & Machine Co., 6 pp, ill. Specification chart for ferrous and nonferrous alloys for centrifugal castings. (284)

**Stampings.** Variety Machine & Stamping Co., 4 pp, illus. Describes plant's facilities for, and variety of stampings. (137)

**Aluminum Bronze Alloys.** W W Alloys, Inc., 32 pp, illus. Basic information on composition and functions of aluminum bronze alloys in castings and includes specifications and machining recommendations. (138)

**Thermometals and Special Alloys.** H. A. Wilson Co., 2655 U. S. Route 22, Union, N. J., 192 pp, price $3.00. New Blue Book on thermostatic bimetals, sintered metals, electrical contact materials, composite and laminated metals and special alloys. Provides design

# Manufacturers' Literature

data, graphs, formulae and properties and applications of hundreds of materials. Also lists production executives, purchasing agents in the field. Write direct to Wilson on company letterhead.

### Nonmetallic Materials • Parts • Forms

**Plastic Molding.** Ackerman Plastic Molding Div., 4 pp, ill. Long run production of plastic parts by compression of plunger molding. (140)

**Lubrication.** Alpha Molykote Corp., 4 pp. Describes principle of lubrication by solids and role of molybdenum disulfide in this process. (141)

**Plastic Pipe.** American Agile Corp., 12 pp. Charts give physical and mechanical properties of polyethylene and polyvinyl chloride pipe and tubing and their chemical resistance to various reagents. (142)

**Filter Mat.** American Felt Co., 6 pp, ill. Technical data and sample of Dynel Windsor Felt, a new fiber-bonded filter mat for use in filter press or vacuum filter applications. (143)

**Fiber Glass Reinforced Plastics.** Apex Electrical Mfg. Co., 4 pp, illus. Case histories of custom molded fiber-glass parts featuring pressure vessels. (144)

**Gasket Materials.** Armstrong Cork Co., 24 pp, ill. Complete data on various cork and rubber gasket materials made to meet government specifications. (145)

**Gaskets, Packings, Etc.** Auburn Mfg. Co., 3 pp, ill. Discusses the various products produced by this company, including gaskets, packings, washers, spacers, seals, shims and bushings. (146)

**Rubber Processing.** Automotive Rubber Co., Inc., 12 pp, illus, No. 500. Describes plant's facilities for fabricating and rubber coating special production parts. (147)

**Coated Abrasives.** Behr-Manning Corp., 60 pp, illus. Compilation of technical papers on coated abrasive grinding and polishing techniques. Covers coated abrasives theory and practice, contour polishing and grinding, part sizing and deburring, etc. (148)

**Woven Glass Roving.** Bigelow-Fibre Glass Prods. Div., Bigelow-Sanford Carpet Co., Inc., 2 pp. Describes mechanically bonded glass fabric used in reinforced plastics, and lists advantages. (149)

**Molding Compounds, Resins and Cements.** The Borden Co., Durite Div., 8 pp, ill, No. 10M. General properties and uses of Durite specially prepared phenolic molding compounds, resins and cements. (150)

**Plastic Sheets.** Cast Optics Corp., 12 pp. Technical properties and fabrication data of clear cast thermoset "Cocor" sheet. (151)

**Polyethylene Sheeting.** Celanese Corp. of America, 6 pp, NP-13. Physical and chemical properties of polyethylene sheeting for tank linings, molded items, ducts, etc. (152)

**Compounded Elastomers.** Chicago Rawhide Mfg. Co., 32 pp, ill. Characteristics, properties and engineering applications of Sirvene compounded elastomers. (153)

**Contact Pressure Laminating Resins.** Ciba Co., Inc., 17 pp, No. 1. Technical data on Araldite contact pressure laminating resins. Includes technical and electrical properties, charts and tables, mold preparation, glass fiber reinforcement, and manufacturing procedures. (154)

**Reinforced Fiberglass Parts.** Clearfield Plastics, Inc., 22 pp, illus. Discusses company's facilities for producing molded contoured parts. Suggests design and specification techniques. (155)

**Coated Fabrics.** Connecticut Hard Rubber Co. Uses, chemical, electrical and mechanical properties, and availability of heat resistant silicone rubber coated glass fabrics. (156)

**Bonded Mica Insulation.** Continental-Diamond Fibre Div., Budd Co., Inc., 14 pp, illus, No. M-55. Micabond bonded mica insulation products in fabricated parts, plates, segments, tapes, tubes and "V" rings. (237)

**Plastic.** Crane Packing Co., 12 pp, ill, No. T-103. Complete data on Chemlon packings and gaskets fabricated from the new tetrafluoroethylene resin, Teflon. (157)

**Thermoplastics.** Dow Chemical Co., 20 pp, illus. Properties of forms of Styron, Ethocel, Saran, Vinyl supplied by Dow, with illustrated applications and outline of Dow's technical service facilities. (158)

**Neoprene Notebook.** Elastomer Div., E. I. du Pont de Nemours & Co., Inc., 8 pp, illus, No. 66. Reports developments and illustrates uses of neoprene. (240)

**Polyester Film.** E. I. du Pont de Nemours & Co., Inc., Film Dept., 22 pp, illus. Discussion of range of applications of Mylar. (159)

**Nylon Resin.** E. I. du Pont de Nemours & Co., Inc., Polychemicals Div., 54 pp. Describes "Zytel" a nylon resin supplied as molding powder for conversion into wire-coatings, rods and other extruded shapes. Final products have outstanding toughness, abrasion resistance, form stability at high temperatures, and chemical resistance. (160)

**Electroformed Molds.** Electromold Corp., 4 pp. Gives details of electroforming process for plastic molds. (161)

**Molding Compounds.** Fiberite Corp., 1 p. No. 6. Lists phenolic melamine and other resin-based molding compounds. (162)

**Laminating Materials.** Flexfirm Products. A folder with 7 technical bulletins Nos. 1, 2, 3, 111, 112, 113, 105 and fabrication instruction for polyester resin impregnated glass cloth mat supplied in dry state ready for layup. (163)

**To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 69 and 70**

**Epoxy Resins.** Furane Plastics, Inc., 10 pp. Set of handy cards giving mixing directions and formulae for casting and laminating resins. (164)

**Plastic Products.** General American Transportation Corp., Plastics Div., 10 pp, ill. Brochure shows plant facilities for production from blueprint through assembly and packing. Also lists wide variety of this company's molded plastics. (165)

**Plastics Designs.** Chemical & Metallurgical Div., General Electric Co., illus. Two booklets, "The Plastics Story" and "Fabricated Silicone Rubber Parts", describe case histories and latest applications. (166)

**Glass Reinforced Plastic.** The Glastic Corp., 2 pp. Data on fiber glass reinforced polyester laminate sheets. (167)

**Self-Lubricating Bushings.** Graphite Metallizing Corp., 8 pp, ill, No. 108. Describes Graphalloy grades for bushings and electrical uses. Bearing design data included. (168)

**Graphite.** Graphite Specialties Corp., 4 pp, No. GS 101-1. An impervious graphite, more than 99.5% pure carbon for high temperature parts. Chemical resistance data and physical properites including heat effects to 5700 F are charted. (169)

**Insulation Hardboard.** Great American Industries, Inc., Rubatex Div., 16 pp, ill. Design data for building insulation applications of Rubatex Hardboard (expanded synthetic rubber compound). (170)

**Injection Molded Plastic.** Gries Reproducer Corp., 4 pp, illus. Illustrates how design engineers can solve planning and production problems with tiny thermoplastic parts. (171)

**Polyester Resins.** Hooker Electrochemical Co. Folder of data sheets describing fire-resistant and polyester resins. (172)

**Polyester Resins.** Interchemical Corp., 6 pp. Summary of physical properties and suggested applications of company's polyester resins and accessory products. (173)

**Hydraulic-Setting Refractories.** Johns-Manville, 12 pp, illus. Describes methods used to produce five types of Firecrete and three types of Blazecrete, hydraulic setting refractories for services through 3000 F, and suggests uses for them. (252)

**Oils and Waxes.** M. W. Kellogg Co., 16 pp, illus. Describes series of polymer products based on polychlorotrifluoroethylene molecule for oils, waxes, and greases. (174)

**New Polyethylene.** Koppers Co., Inc., 16 pp, illus. Properties and uses of Super Dylan polyethylene. A tougher, stronger thermoplastic that will withstand sterilization temperatures. (175)

**Industrial Lens.** Lancaster Lens Co., 4 pp, ill. Shows a variety of industrial glass products produced by this company, and lists the many industries it serves. (176)

**Rubber Design Handbook.** Lavelle Rubber Co., 80 pp, illus, No. MT-56. Basic facts pertaining to the design of custom-made rubber and rubber-like articles are given in this thumb in-

dexed handbook, together with actual samples of products. (177)

**Glass.** Libbey-Owens-Ford Glass Co., 8 pp, ill. Glass in product and engineering design. (178)

**High-Impact Thermoplastic Resin.** Marbon Corp., 20 pp, No. CY-2. Processing recommendations, physical data, chemical resistance data and results of aging tests for Cycolac, a new resinous polymer in which the basic material is styrene. (285)

**Reinforced Wood.** Met-L-Wood Corp., 15 pp, illus, No. 521. Describes combined wood and metal sheets, providing light weight and high strength. (179)

**Insulating Material.** Mica Insulator Co. Catalog of standard electrical insulating materials. (180)

**Glass Reinforced Plastics.** Molded Fiberglass Co., 6 pp, illus. Facilities for producing glass fiber reinforced plastics molding. (181)

**Glass Bonded Mica.** Mycalex Corp. of America, 24 pp, illus. Design information for parts to be machined from glass bonded mica. (182)

**Plastics Pipe.** National Tube Div., U.S. Steel Corp., 28 pp, illus, No. 24. Data presented on unplasticized rigid polyvinyl chloride pipe both normal and high impact types. Describes installation techniques. (286)

**Vulcanized Fibre.** National Vulcanized Fibre Co., 18 pp, illus. Brochure gives broad picture of this material, including how it is made, its outstanding properties, fabrication and forming, shapes and grades available, and representative applications. (264)

**Boron Carbide.** Norton Co., 16 pp, illus. A handbook on boron carbide, elemental boron, and other stable, boron-rich materials. (127)

**Insulations.** Owens-Corning Fiberglas Corp., 8 pp, illus, No. GL6.C4. Describes fiber insulations having low thermal conductivity and high sound absorption qualities. (183)

**Nonmetallics.** Polymer Corp. of Pennsylvania, 4 pp, illus. Describes properties and characteristics of a line of nylon, Teflon and specialty nonmetallics. (184)

**Corrosion Resistant Gasketing.** Products Research Co., 5 pp, ill. Features, advantages and specifications of Chromelock corrosion resistant gasketing material. (185)

**Tooling Plastics.** Ren-ite Plastics, Inc., 4 pp, illus, No. 1001. Describes dimensionally stable tooling plastic for use in laminating or casting without application of heat or pressure. (186)

**Phenolics in Plastic Tooling.** Rezolin, Inc., 6 pp, No. 107. Information on use of phenolics in plastic tooling. Includes property data and applications. (187)

**Molded Plastics.** Richardson Co., 12 pp. illus. Describes types and grades of laminated and molded plastics. Applications given. (188)

**Gasket Materials.** Rogers Corp., 12 pp. General data and recommendations for using Duroid gasket materials, and data sheets on seven specific gasket sheeting materials, which include a general description, typical test values and service recommendations. (271)

**Plastic Molding.** Romar Plastics, Inc., 4 pp, illus. Describes company's facilities for all stages of plastic molding. (189)

**Plastic Molding.** Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for producing molded parts and products, including automatic injection molding machines with capacities ranging from 4 to 60 oz. (190)

**Plastic Molding Presses.** F. J. Stokes Machine Co., 8 pp, ill, No. 525. Describes complete line of Stokes automatic-semi-automatic, performing and extrusion presses. (191)

**Rubber.** Sun Rubber Co., 22 pp, illus. Describes plant's facilities for processing, curing and finishing rubber products. (192)

**Polyurethane Foam.** Surface Chemicals Inc., 4 pp. Properties of Isothane foam for thermal insulation and sound control. (287)

**Machining Laminated Plastics.** Synthane Corp., 6 pp, ill. Recommended techniques for common machining operations on laminated plastics. Includes properties and design hints. (193)

**Fabricating Laminated Plastics.** Taylor Fibre Co., 15 pp. Reprints of NEMA-authorized engineering information: Recommended Practice for Fabricating Laminated Plastics. (194)

**Coated Fabric.** Textileather Div., General Tire & Rubber Co., 6 pp, illus. Introduces Nygen Tolex and nylon reinforced coated fabrics. (195)

**Pipe Fittings and Flanges.** Tube Turns Plastics, Inc., 12 pp, illus. Drawings and data on fittings and flanges made of unplasticized polyvinyl chloride. (196)

**Nylon Screws.** Weckesser Co., 3 pp, illus. Describes black nylon screws and nuts, use in design problems, and price list for various types. (197)

## Finishes • Cleaning and Finishing

**Chromate Conversion Coatings.** Allied Research Products, Inc., 4 pp, ill, No. 8. Complete data on the basic characteristics of Iridite chromate conversion coatings, and their functions on various metals. (199)

**Cleaning and Finishing Media.** Almco Div., Queen Stove Works, Inc., 10 pp. illus. Features and applications of Super-sheen Abrasive Chips and Compounds for barrel finishing and cleaning. Also data on finishing machines. (200)

**Metal Protection and Paint Bonding.** American Chemical Paint Co., 4 pp, illus, No. 3d/Am. Protective inorganic finishes which improve paint adhesion, corrosion resistance and facilitate metal forming operations. (201)

**Protective Coatings.** Bisonite Co., Inc., 24 pp, illus. Folder of descriptive data on vinyl, phenolic, rubber, acrylic, silicone, furfuryl-alcohol and specialty coatings. (202)

**Protective Coatings.** Ceilcote Co., 8 pp, illus, No. C-150. Gives base formulations, chemical properties and adhesion characteristics of seven standard organic coatings. Includes simplified chart for selecting coatings, surface treatment, processes, etc. (203)

**Metallic Abrasives.** Cleveland Metal Abrasive Co., 16 pp, illus. Discusses three types of metallic abrasives and selection of abrasion method. (235)

**Enameled Metal Strip.** Coated Coils Corp., 4 pp, ill. Describes coiled enameled metal strip supplied in widths up to 30 in. which can be put through operations without damaging the coating. (204)

**Molded and Extruded Rubber.** Continental Rubber Works, 8 pp, No. 100. Gives dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (205)

**Zinc Phosphate Coatings.** Cowles Chemical Co., 4 pp. Properties of amorphous and crystalline non-sludging zinc phosphate coatings. (206)

**Phosphate Coating.** Detrex Corp., 6 pp, illus. Describes low-cost phosphate coating process that protects iron and steel from corrosion. (207)

**Black Oxide Finish.** Du-Lite Chemical Corp. Information on Du-Lite finishes for any steel blackening problem. Also gives information on Du-Lite cleaner, strippers, burnishing compounds, etc. (208)

**Air Dry Lubricant.** Electrofilm Corp., 4 pp, ill. Complete data on Lubro-bond, a dry film lubricating compound specifically designed to meet the anti-friction requirements of industry. Prices included. (288)

**Wear Resistant Coating.** Electrolizing Corp., 16 pp. Detailed data on the Electrolizing Process for increasing the life and efficiency of metal parts subjected to wear, abrasion and corrosion. (209)

**Metallized Ceramic Coating.** Frenchtown Porcelain Co., 4 pp, illus. Metal-to-ceramic coating produces surface to which metal part or other metallized ceramic parts may be soft or hard soldered without special preparation. (210)

**Adhesives and Coatings.** Houghton Laboratories, Inc., 96 pp. Bound volume of technical bulletins and price lists covering adhesives, coatings and plastics materials. (211)

**Protective Coatings.** Industrial Metal Protectives, Inc., 8 pp, illus, No. Z-853. Zincilate self-protecting anti-corrosion coatings for metal parts and products. (212)

**Cleaning Automotive and Aircraft Parts.** Kelite Products, Inc., 2 pp, ill, No. 17-R. Degreasing and decarburizing agent. Formula 555, for aircraft and automotive parts. (253)

**Chemical Resistant Coatings.** McDougall-Butler Co., Inc., 4 pp, illus. Describes chemical resistant coating used without primer on metal and wood surfaces. (213)

**Sprayed Metals.** Metallizing Engineering Co., Inc., 6 pp, illus, No. 120. Illustrates a wide range of applications of metallizing, sprayed metal, in the production of electrical and electronic equipment. (214)

# Manufacturers' Literature

**Colored Silicone Finishes.** Midland Industrial Finishes Co., ill. Reprint interestingly discusses the application of colored slicone finishes. (215)

**Aluminum-Chromium Paint.** Monroe Co., Inc., 4 pp, illus, No. C-54-8. Includes detailed application data on Monco-Alochrom, an aluminum-chromium paint for exterior and interior surfaces of all kinds. (216)

**Wrinkle Finishes.** New Wrinkle, Inc., illus. Folder shows typical products utilizing Wrinkle finishes. (217)

**Stripper.** Northwest Chemical Co., 1 p. A liquid stripper to remove organic finishes from plastics, particularly imperfect articles. (267)

**Phosphate Coating.** Pennsylvania Salt Mfg. Co., 5 pp, illus. Description of the Fosbond process of phosphate coatings for metal finishing. (218)

**Fluorine Resin Coatings.** Permolite, Inc., two 4-page bulletins. Fluor-O-Alloy coatings based in trifluorochloroethylene polymer. Includes corrosion resistance data and application data. (219)

**Industrial Brushes.** Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Ave., Baltimore, Md. Case histories indicate economics available to users of Pittsburgh brushes. Write direct to Pittsburgh Plate Glass on company letterhead.

**Polyvinyl Chloride Coatings.** Quelcor, Inc., 4 pp, illus, No. 53 A. Polyvinyl chloride coatings fused and flowed on metal for corrosion protection. (220)

**Ceramic Coatings.** Solar Aircraft Co., 8 pp, illus. Uses and properties of Solaramic coatings, a family of proprietary ceramic coatings designed to protect high or low alloy steel fabrications from heat and/or corrosion. (221)

**Corrosion Resistant Coating.** Specialty Coatings, Inc., Div. of Thompson & Co., 6 pp, illus. Examples of how Vinsynite Pretreatment was used in finishing six different types of metal products for good paint adhesion and corrosion resistance. (222)

## Methods and Equipment

**Heat Treating Equipment.** American Gas Furnace Co., 24 pp, illus, No. C-1304. Covers company's line of blow pipes, forges, pot furnaces brazing and industrial heating machines, etc. Copy may be obtained by writing directly to American Gas Furnace Co., 140 Spring St., Elizabeth, N. J., on company letterhead.

**Silver Brazing.** American Platinum Works, 48 pp, ill. Reference manual on silver brazing, discusses low temperature brazing, brazing alloys, design considerations and other topics. (225)

**Test Chambers.** American Research Co., 4 pp, ill. Describes the basic environmental test chambers produced by this company for testing under a variety of conditions. (226)

**Welding Insert.** Arcos Corp., 10 pp, ill. Welding process technique where welding is done on one side only by means of insert process. Suitable for butt welding of stainless and alloy steel pipe, both seamless and welded. (228)

**Indicating Extensometer.** Baldwin-Lima-Hamilton Corp., Eddystone Div., 8 pp, ill, No. 4212. Description of various types of extensometers with specifications. (229)

**Grating Spectrographs.** Bausch & Lomb Optical Co., 8 pp, illus, No. D-272. Describes spectrograph with two gratings for greater dispersion flexibility. (230)

**Chains.** The Bead Chain Mfg. Co., 12 pp, illus. Bead chain characteristics and applications are described. (231)

**Metallurgical Testing Equipment.** Buehler Ltd., 12 pp, illus. Describes metallurgical specimen mount presses. (232)

**Heat Treating Ovens.** Carl Mayer Corp., 6 pp, illus, No. HT-53. Brief description of various types of heat treating furnaces and ovens. (233)

**Decimal Equivalent Chart and Calendar.** Dayton Rogers Mfg. Co., 2824 13th Ave., Minneapolis 7, Minn. Combination calendar and decimal equivalent chart available. Write direct to Dayton Rogers Mfg. on company letterhead.

**Sintering Furnaces.** Drever Co., 12 pp, illus, No. B-101. Describes types of furnaces for sintering metal powder products. (238)

**Metalworking Tools.** The Eaton Co., 34 pp, illus. Describes representative gear production machines and tools. (239)

**Heat Treating Furnaces.** The Electric Furnace Co., 4 pp, ill. Shows various gas, oil and electric furnaces for annealing and heat treating requirements and lists applications. (241)

**Reducing Atmosphere Generators.** Gas Atmospheres, Inc., 4 pp, ill, No. R-352. Atmosphere generators for industrial applications such as bright hardening, annealing, gas carburizing and sintering. (242)

**Rotary Hearth Furnaces.** Gas Machinery Co., 4 pp, ill, No. A-102. Complete specifications of the Gasmaco rotary hearth furnaces for forging, annealing, heat treating or drawing operation. (243)

**Temperature Controls.** Claude S. Gordon Co., 4 pp, ill. Brief description and advantages of straight line, fully automatic temperature control. (244)

**Brazing.** Handy & Harman. 4 pp, illus. No. 17. Instructions for brazing fittings to pipe and tubing with low temperature silver alloy. (245)

**Conveyor Furnaces.** Harper Electric Furnace Corp., 4 pp, illus, No 454. Describes mesh belt conveyor furnaces. Gives specifications and dimensions. (246)

**Lock Washers.** Hobbs Mfg. Co., 4 pp, illus No. 255. Price list of a complete line of Tangle-Proof high carbon steel, stainless steel and silicon and phosphor bronze lock washers. (248)

**Heat Treating.** Holcroft & Co., 12 pp, illus. Information on various types of Holcroft furnaces. (249)

**Pyrometers.** Illinois Testing Labs, Inc., 6 pp, illus. Thermoelectric pyrometer for precision measurements of temperatures beyond 1000 F. (250)

**Tablet Presses.** Kux Machine Co., 4 pp, illus. Tabletting presses for production of powdered metal parts, ceramic parts, explosives, etc. (254)

**High Frequency Heating Units.** Lepel High Frequency Laboratories, No. MM-7. Specifications, features and advantages of this company's low cost, high frequency heating units. (255)

**Silver Brazing Preforms.** Lucas Milhaupt Engineering Co., 12 pp, illus. Formed shapes of brazing filler metals to simplify brazing operations. (256)

**Induction Heaters.** Magnethermic Corp., 12 pp, illus. Describes low frequency brass and copper induction heaters for preheating metals. (257)

**Arc Welding Electrodes.** Metal & Thermit Corp., 36 pp. Descriptive information, chemical and physical data, and recommended procedures for mild steel and low alloy welding. Other engineering data included. (259)

**Induction Heating Control.** Minneapolis-Honeywell Regulator Co., 16 pp, illus, No. HT-1. Discusses automatic temperature control for induction heating equipment. (260)

**Dispensers and Taping Machines.** Minnesota Mining & Mfg. Co., 16 pp, illus. Manual containing types of dispensers and taping machines for pressure-sensitive tape. (261)

**Spectrograph.** National Spectrographic Sales Corp., 8 pp, illus. Spectrographic equipment and accessories. (263)

**Welding Studs.** Nelson Stud Welding, Div. of Gregory Industries, Inc. Wall Chart No. 1. Dimensions and applications of standard MG studs. 12-pp booklet also available. (265)

**X-ray Analysis.** North American Philips Co., Inc., 7 pp. Explains difference in x-ray powder camera, diffractometer and spectrograph equipment and techniques. Outlines specimen preparation, application fields, calibration and selection of analyzing crystals for spectrograph work. (266)

**Hole Quencher.** Palmer Mfg. Co., 4 pp, illus. Features advantages of using the I. D. Hole-Quencher for case hardening holes seven times faster. (268)

**Electric Furnaces.** Pereny Equipment Co., 3 pp, illus, No. 4A. Booklet tells advantages and illustrates typical group of furnaces and kilns and their uses. (270)

**Wax Injection Presses.** Alexander Saunders & Co., 8 pp, illus. Specifications and prices on wax injection presses for investment casting. (274)

**Resistance Welding.** Sciaky Bros., Inc., 4 pp, illus, Vol. 4, No. 4. Case history of resistance welding in the U.S. Air Force Northrop F-89D. (275)

**Tensile Testing Machines.** Scott Testers, Inc., 6 pp, illus, No. 55. Shows wide assortment of testing machines for testing tensile strength of materials such as rubber, paper, wire and thread. (276)

**Welding Process.** Westinghouse Electric Corp., 7 pp, No. B-6525. Describes performance and applications of consumable electrode inert gas welding process. (277)

# One point of view

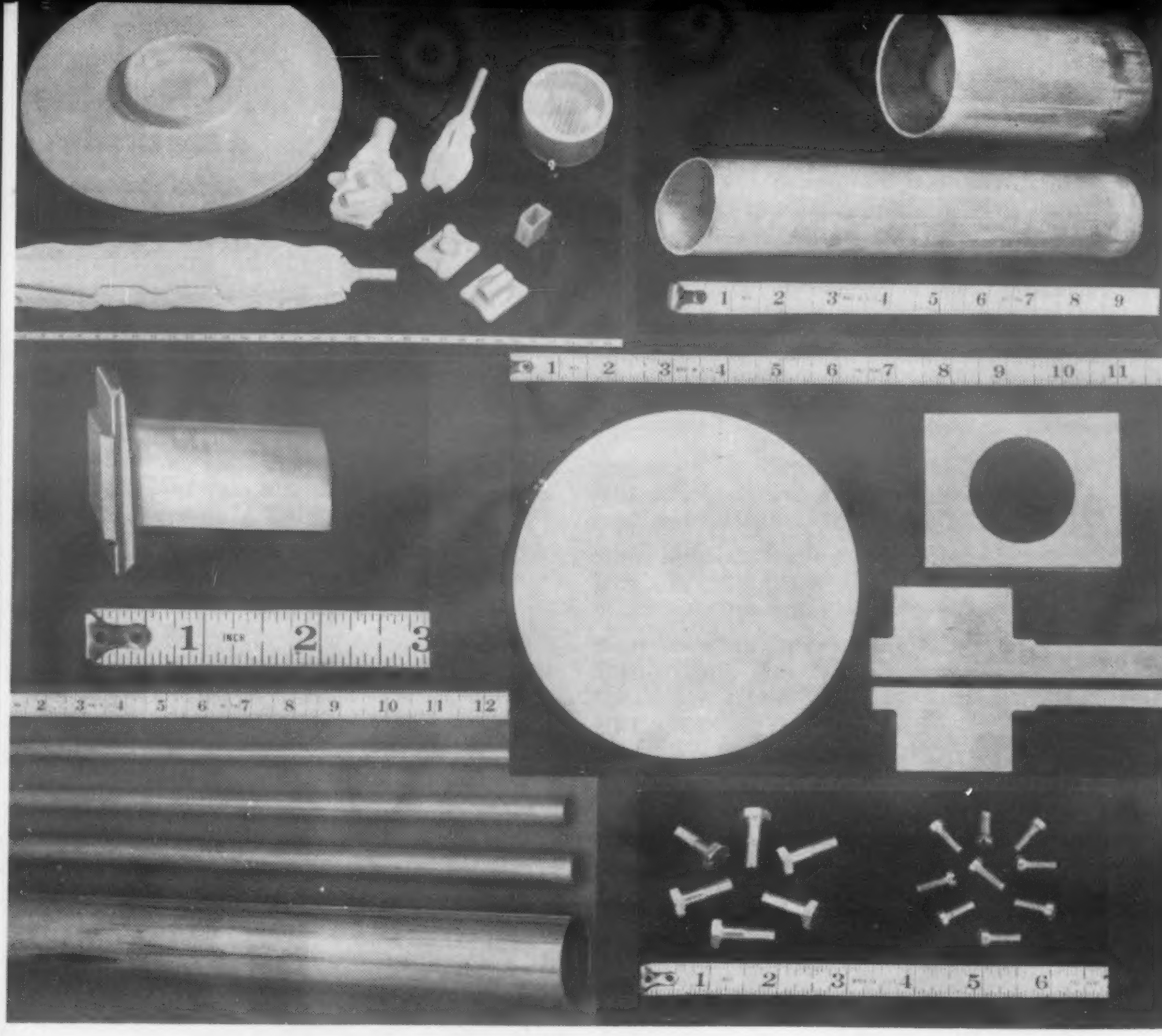
*Stainless Steels and the Nickel Shortage*

If you are a present or potential user of stainless steels, there is a good chance that within the next six months or so you will be obliged to use some of the newer grades of stainless in place of the popular 18:8 types. The reason, of course, is the persistent nickel shortage. Although nickel production is up about 10%, the supply still is not enough to satisfy both Uncle Sam's hungry stockpile and unprecedented civilian demands. So, we may as well face it—the nickel shortage will be with us for a long time.

Because nickel is short does not mean that you must do without stainless. During and since World War II, new low-nickel grades have been developed. But because of certain production difficulties, the steel industry, until recently, has been reluctant to push them. Now, however, two low-nickel, high-manganese compositions have been named as standard AISI steels, and a number of steel companies are planning to produce them as tonnage items. From all reports, these new standard grades (types 201 and 202) are similar in properties and cost to the familiar types 301 and 302.

There are other alternate grades worth considering, namely, the straight chromium grades (400 series) and special ferritic types for high temperature service. These steels have properties that will fit many of your needs as well as the nickel-bearing grades have in the past.

To assist you in selecting the right alternate stainless steels, we have published in this issue a 16-page article (an M&M manual) on "The New Stainless Steels" (page 137). We believe it is the first comprehensive article on this critical subject, and we hope you find it helpful.



*Many different shapes can be produced from the M257 alloy.* **Die Forgings** *(upper left).* **Impact Extrusions** *(upper right).* **Forged Blade** *(center left).* **Extruded Shapes** *(center right).* **Tubing** *(lower left).* **Fasteners** *(lower right).*

**These parts are . . .**

# Aluminum Powder Metallurgy Products

*Compacts of fine aluminum powder containing aluminum oxide have outstanding strengths above 600 F. Two APM alloys, designated M257 and M276, raise the useful range of aluminum alloys by about 300 F.*

**by John P. Lyle, Jr.** *Aluminum Company of America*

■ Following the discovery in Switzerland of the unique characteristics of wrought products made from fine aluminum powder containing large amounts of aluminum oxide (SAP), extensive development of products of this type has occurred both in the United States and in Europe. The object of these new developments is to produce extrusions, forgings and sheet having higher strengths at elevated temperatures than the same products have when made from conventional alloys, rather than the production of finished parts of closely controlled dimensions.

The process used for making APM (aluminum powder metallurgy) products consists of making a compact of fine aluminum powder and extruding or forging the compact to the desired shape. At the present time, compacts as large as 21 in. dia and weighing as much as 800 lb are being made experimentally. In some cases, the extruded piece serves as stock for further fabrication by forging, rolling, or drawing. The powder used is of commercial purity (99% or purer) except for the oxide content.

## Applications

In the interest of rapid progress, greater emphasis has been placed on M257 than on M276 which is more difficult to fabricate. Since customers usually need something more elaborate than the small diameter extruded rods used for tests reported on p. 107, the product must have a combination of strength and workability. It has been found that M257 is a good compromise because it is stronger above 600 F than the best conventional wrought aluminum alloys and can be fabricated into a wide variety of products. Improved products having the same strengths as M256 will be available in the future.

M257 sheet is rolled in the commercial range of thicknesses. Widths as great as 48 in. and lengths of 144 in. and more have been rolled, but the size of available rolling stock presently limits rolling operations to hand-fed mills. Tensile strength of M257 sheet is higher than strength of extrusions at both room temperature and 600 F. Formability of M257 sheet appears to be about the same as that of 7075-T6. M257 sheet can be easily combined with other alloys to form clad materials. For example, 2024 sheet has been clad with M257 and M257 sheet has been clad with 3003. M257 foil has been successfully hand-rolled in 24 in. widths to thicknesses down to 0.0014 in.

M257 sheet is being tested as various kinds of heat shields. Honeycomb sandwiches consisting of M257 foil core with M257 sheet facings have been made and tested.

Larger scale tests are now in progress.

The high strength, thermal conductivity, and melting point of M257 are expected to make extrusions and forgings useful in pistons and cylinder heads for reciprocating engines. The part may be made entirely of M257 or the M257 may be inserted in the hot spot of a part otherwise made of a cast or wrought aluminum alloy.

Typical extruded shapes are shown in photograph. Rod 6 in. in dia has been used for spacers, heat seal rings and forging stock while 2¼-in. dia rod has been machined into pistons. Shapes have been machined into hot air valve housings and pneumatic cylinders.

M257 die forgings are illustrated also. The largest piece is a compressor disk about 21 in. in diameter, weighing about 33 lb. The part in upper right of group is a rough machined aircraft piston. Below the piston is an impact forging. The long, thin piece below the compressor disk is a fan blade from which the flash has not been trimmed. The two untrimmed pieces between the piston and the compressor disk are forged aircraft fittings. The two trimmed pieces in the lower right portion of the group are end caps for the pneumatic cylinder mentioned in the preceding paragraph on extrusions.

Tubing has been produced also. The largest size illustrated is 1.625 in. o.d. by 0.030-in. wall. The smallest tubing was made for test in an airborne heat exchanger.

Impact extrusions have been made from M257 also. Illustrated are a short cup (2¼) in. dia by 0.090-in. wall by 4⅛ in. deep and another part 1½ in. dia by 0.030 in. wall by 8½ in. deep.

Rivets, bolts and screws have been made from M257 wire. The rivets illustrated are 3/16 in. x ⅜ in. universal head rivets; the screws are 10/32 x ½-in. fillister head.

## Properties

Properties of the final APM product are influenced, greatly by the particle size, shape and oxide content of the powder and by variables in compacting and subsequent fabrication.

### Short-time properties

APM products are characterized by unusually high strengths and stability above 600 F. The strengthening mechanism is probably similar to that in the precipitation-hardened alloys with the oxide particles serving the function of the precipitate to prevent slip. Since they are insoluble, the particles of oxide cannot redissolve at elevated temperatures, and APM alloys maintain their strengths at higher temperatures and for longer times than do heat-treatable alloys.

Elevated temperature tensile and yield strengths of extrusions of two APM alloys, M257 and M276, are compared with three conventional alloys in Fig 1. The APM products have lower strengths than 2024-T4, 2618-T61, and X2219-T6 at 400 F, but above 500-650 F, the APM alloys are superior to the best of the conventional alloys. Since the APM alloys are somewhat stronger at 1000 F than X2219-T6 is at 700 F, it may be said that APM products extend the useful range of aluminum by about 300 F.

An unusual characteristic of APM products is the decrease in

**TABLE 1—NOMINAL COMPOSITIONS OF SOME WROUGHT ALUMINUM ALLOYS**

| Alloy | % Alloying Element | | | | |
|---|---|---|---|---|---|
| | Cu | Si | Mn | Mg | Other |
| 1100 | 99% Min Aluminum | | | | |
| 2014 | 4.5 | 0.09 | 0.08 | 0.05 | — |
| 2024 | 4.5 | — | 0.65 | 1.5 | — |
| 2117 | 2.5 | — | — | 0.3 | — |
| X2219 | 6.0 | — | 0.3 | — | 0.10 V, 0.15 Zr |
| 2618 | 2.2 | — | — | 1.6 | 1.1 Fe, 1.05 Ni, 0.07 Ti |
| 3003 | — | — | 1.2 | — | — |
| 4032 | 0.9 | 12.2 | — | 1.1 | 0.9 Ni |
| 6061 | 0.25 | 0.6 | — | 1.0 | 0.25 Cr |

*Aluminum and normal impurities, remainder.*

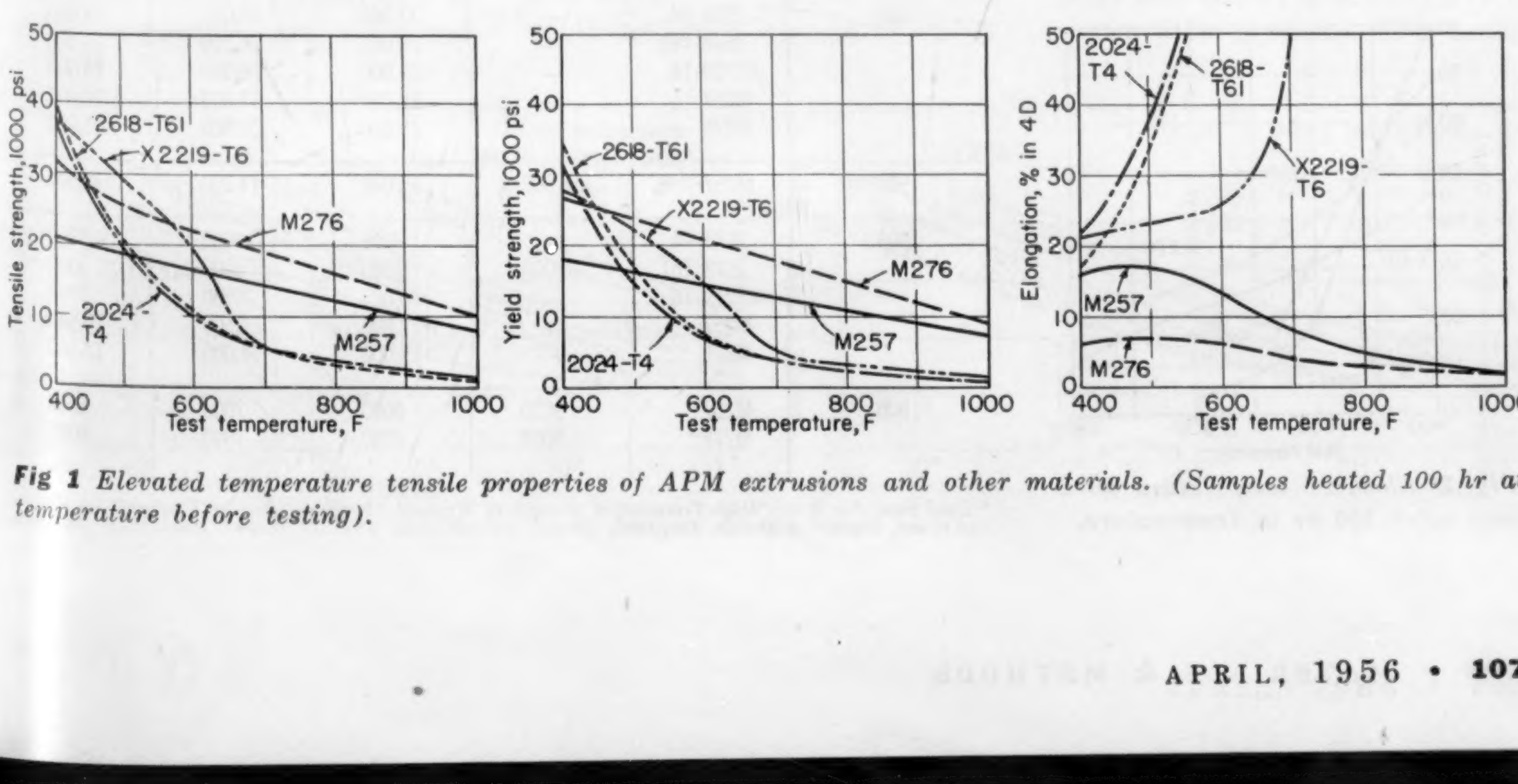



**Fig 1** *Elevated temperature tensile properties of APM extrusions and other materials. (Samples heated 100 hr at temperature before testing).*

**TABLE 2—TENSILE PROPERTIES OF WROUGHT ALUMINUM ALLOYS**

| Test Conditions: Temp, F | Time, Hr | M257 Ten Str, psi | M257 Yd Str 0.2% offset, psi | M257 Elong in 4D, % | M276 Ten Str psi | M276 Yd Str 0.2% offset, psi | M276 Elong in 4D, % | 2024-T4 Ten Str, psi | 2024-T4 Yd Str, 0.2% offset, psi | 2024-T4 Elong, in 4D, % |
|---|---|---|---|---|---|---|---|---|---|---|
| Room | — | 37,000 | 24,000 | 17 | 51,000 | 34,000 | 7 | 68,000 | 46,000 | 22 |
| 400 | ½ | 21,000 | 18,000 | 16 | 32,000 | 27,000 | 6 | 51,000 | 36,000 | 25 |
| | 100 | 21,000 | 18,000 | 16 | 32,000 | 27,000 | 6 | 37,000 | 31,000 | 22 |
| | 1000 | 21,000 | 18,000 | 16 | 31,000 | 26,000 | 6 | 31,000 | 27,000 | 24 |
| 500 | ½ | 19,000 | 16,000 | 17 | 26,000 | 23,000 | 7 | 29,000 | 23,000 | 22 |
| | 100 | 19,000 | 16,000 | 17 | 26,000 | 23,000 | 7 | 20,000 | 15,000 | 38 |
| | 1000 | 19,000 | 16,000 | 17 | 26,000 | 23,000 | 7 | 16,000 | 12,000 | 42 |
| 600 | ½ | 17,000 | 15,000 | 13 | 22,000 | 20,000 | 6 | 15,000 | 12,000 | 35 |
| | 100 | 17,000 | 15,000 | 13 | 22,000 | 20,000 | 6 | 10,000 | 7500 | 65 |
| | 1000 | 17,000 | 15,000 | 13 | 22,000 | 20,000 | 6 | 8000 | 5500 | 70 |
| 700 | ½ | 14,000 | 13,000 | 8 | 19,000 | 18,000 | 4 | 7500 | 6000 | 55 |
| | 100 | 14,000 | 13,000 | 8 | 19,000 | 18,000 | 4 | 5500 | 4000 | 95 |
| | 1000 | 14,000 | 13,000 | 8 | 19,000 | 18,000 | 4 | 5000 | 3500 | 100 |
| 800 | ½ | 12,000 | 11,000 | 5 | 16,000 | 15,000 | 3 | — | — | — |
| | 100 | 12,000 | 11,000 | 5 | 16,000 | 15,000 | 3 | — | — | — |
| | 1000 | 12,000 | 11,000 | 5 | 16,000 | 15,000 | 3 | — | — | — |
| 900 | ½ | 11,000 | 10,500 | 4 | 13,000 | 12,000 | 3 | — | — | — |
| | 100 | 11,000 | 10,500 | 4 | 13,000 | 12,000 | 3 | — | — | — |
| | 1000 | 11,000 | 10,500 | 4 | 13,000 | 12,000 | 3 | — | — | — |
| 1000 | ½ | 7500 | 7000 | 2 | 10,000 | 9000 | 2 | — | — | — |
| | 100 | 7500 | 7000 | 2 | 10,000 | 9000 | 2 | — | — | — |
| | 1000 | 7500 | 7000 | 2 | 10,000 | 9000 | 2 | — | — | — |

elongation with temperature. This contrasts with the behavior of conventional alloys. The elongations of M257 are higher than those of M276, a condition which is reflected in the workability of the two alloys.

The elevated temperature stability of APM products may be shown by comparing tensile properties after various time periods. Tensile and yield strengths of conventional alloys tend to decrease with time at temperature. Table 2 shows for example, that the yield strength of 2024-T4 at 600 F drops from 12,000 psi after ½ hr at temperature to 5500 psi after 1000 hr at temperature, but the yield strength of the APM extrusions are unchanged.

Above 550 or 600 F, the APM extrusions are superior to the best of the conventional alloys, in hard-

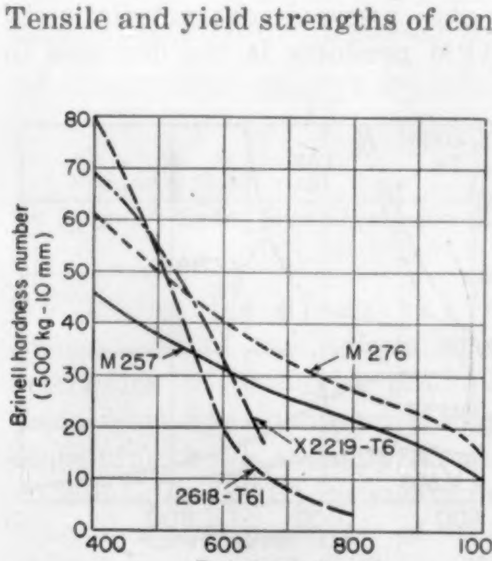



***Fig 2** Elevated temperature hardness after 100 hr at temperature.*

**TABLE 3—STRESS-RUPTURE**

| Temp, F | Alloy | Stress (psi) for Rupture in: 1 Hr | 10 Hr | 100 Hr | 1000 Hr |
|---|---|---|---|---|---|
| 400 | 2024-T4 | — | 33,000 | 26,000 | 18,000 |
| | 2618-T61 | — | 28,000 | 24,000 | 21,000 |
| | X2219-T6 | — | 29,000 | 26,000 | 24,000 |
| | M257 | — | 18,000 | 17,000 | 16,000 |
| | M276 | — | 25,000 | 23,000 | 21,000 |
| 500 | M257 | 16,000 | 15,000 | 14,000 | 13,000 |
| 600 | 2024-T4 | — | 7000 | 4000 | 2700 |
| | 2618-T61 | 10,000 | 7500 | 5000 | 3000 |
| | X2219-T6 | — | 14,000 | 9500 | 7000 |
| | M257 | — | 12,500 | 11,500 | 10,500 |
| | M276 | — | 15,000 | 14,000 | 12,500 |
| 900 | M257* | 9000 | 8000 | 7000 | 6000 |
| | M276* | 9000 | 8000 | 7000 | 6000 |

* *Data from Fig 3 of "High-Temperature Strength of Wrought Aluminum Powder Products" by Gregory and Grant,* Journal of Metals, *Feb, 1954.*

AND APM PARTS AT ELEVATED TEMPERATURES

| X2219-T6 | | | 2618-T61 | | |
|---|---|---|---|---|---|
| Ten Str, psi | Yd Str, 0.2% offset, psi | Elong in 4D, % | Ten Str, psi | Yd Str, 0.2% offset, psi | Elong in 4D, % |
| 62,000 | 43,000 | 16 | 64,000 | 54,000 | 10 |
| 39,000 | 34,000 | 24 | 46,000 | 43,000 | 14 |
| 38,000 | 28,000 | 21 | 39,000 | 34,000 | 17 |
| 38,000 | 27,000 | 21 | 34,000 | 31,000 | 20 |
| 29,000 | 24,000 | 23 | 29,000 | 26,000 | 25 |
| 29,000 | 22,000 | 24 | 21,000 | 17,000 | 35 |
| 29,000 | 22,000 | 24 | 19,000 | 13,000 | 45 |
| 21,000 | 17,000 | 25 | 21,000 | 18,000 | 30 |
| 20,000 | 15,000 | 25 | 11,000 | 7500 | 65 |
| 18,000 | 14,000 | 27 | 9000 | 6000 | 75 |
| 12,000 | 10,000 | 29 | 8500 | 6500 | 50 |
| 5500 | 5000 | 62 | 5500 | 4000 | — |
| — | — | — | 5000 | 3500 | — |
| 4000 | 3500 | 65 | 4000 | 3500 | 65 |
| — | — | — | — | — | — |
| — | — | — | — | — | — |
| 2500 | 2500 | 135 | 2000 | 1500 | 135 |
| — | — | — | — | — | — |
| — | — | — | — | — | — |
| 1500 | 1500 | 110 | 1000 | 1000 | 110 |
| — | — | — | — | — | — |
| — | — | — | — | — | — |

ness (see Fig 2). Stability of the APM products is shown also by the residual hardness at room temperature after heating at a definite temperature. Fig 3 shows the residual hardness after 100 hr at temperature. As can be seen, the hardness of the APM extrusions are scarcely changed by heating but the conventional alloys are definitely softened.

**Stress-rupture and creep**

Stress-rupture properties of APM extrusions are compared with the best conventional alloys in Table 3. At 400 F, the conventional alloys are generally stronger but the APM alloys are less affected by time. For example, the difference between the stress to cause failure in 10 hr and that to cause failure in 1000 hr is 7000 psi for 2618-T61 and 2000 psi for M257, a decrease of 25% and 11%, respectively. At 600 F, APM alloys generally have higher stress-rupture strengths than conventional alloys. A stress of 10,500

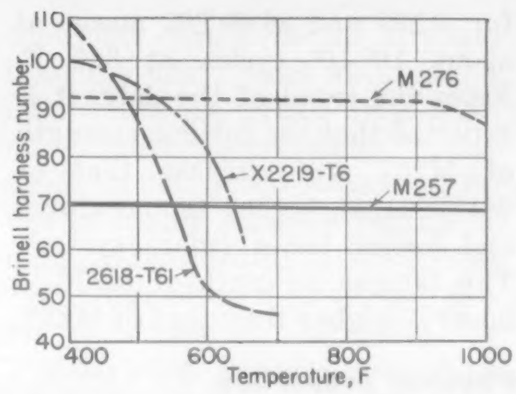



***Fig 3** Residual hardness of several materials after 100 hr at temperature. (Hardness determined at room temperature).*

psi will cause M257 to fail in 1000 hr, and a slightly lower stress will cause X2219-T6 to fail in 100 hr; a stress within the same range will cause 2618-T61 to fail in one hour. As a matter of fact, the APM alloys exhibit as good stress-rupture strength at 900 F as 2618-T6 does at 600 F.

Total creep data at 400 and 600 F are given in Table 4. At 400 F, M276 is about the same as X2219-T6 but M257 is clearly inferior to the conventional alloys. At 600 F, both APM alloys are more resistant to creep than the conventional alloys.

**Fatigue**

Fatigue data also illustrate the relative stability of the APM alloys. In Fig 4, the best conventional alloy from the standpoint of fatigue strength at 400, 500, and 600 F is compared with M257 and M276. Alloy 2618-T61 is generally stronger than M257 under the conditions of the test but the fatigue strength of the conventional alloy decreases materially with temperature. This is in contrast with the APM product which shows little decrease. The bands

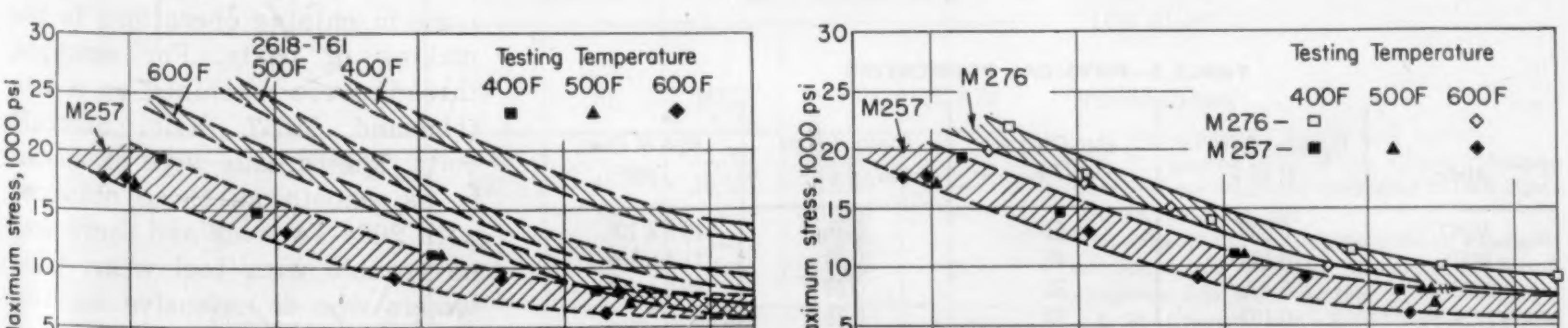



***Fig 4** Elevated temperature cantilever beam fatigue curves.*

for M257 and 2618-T61 merge at about $10^7$–$10^8$ cycles at 600 F. From the trend of the data, it is expected that the fatigue strength of M257 will surpass that of 2618-T61 at higher temperatures and longer times (more cycles). The fatigue strength of M276 is 30-40% higher than that of M257.

### Physical properties

Densities, electrical and thermal conductivities, and moduli of elasticity of APM extrusions are shown in Table 5. APM alloys tend to be slightly less dense than conventional alloys because aluminum oxide is lower in density than alloying additions in the conventional alloys. Conductivities of the APM products tend to be higher than those of conventional products. Thus APM products, particularly M257, have an advantage in applications requiring good elevated temperature strength and good thermal conductivity. The modulus of elasticity of M257 is about the same as that of the conventional alloys listed while that of M276 is higher than M257. In fact, the modulus of M276 is equal to that of 4032 (12% silicon alloy not shown in Table 5) which has the highest modulus of any of the commercial wrought alloys.

The average coefficients of thermal expansion of M257 and M276 are lower than those for the conventional alloys.

### Corrosion

Corrosion and stress-corrosion tests on M257 and M276 are in progress because alloys having a matrix of pure aluminum with a dispersion of aluminum oxide should have interesting corrosion characteristics. As expected, no evidence of stress-corrosion of APM products has been found. Tests are being made also on unstressed specimens. The tests completed so far include one year of alternate immersion (in 3½% NaCl), one year in an industrial atmosphere, one year in 3½% NaCl intermittent spray, 12 wk in tide water, and 12 wk of total immersion in sea-water. From visual examination and measured losses in tensile strength, it appears that the resistance to corrosion of M257 is as good as that of 1100 and 3003, and superior to 2024-T4 and 6061-T6. M276 is inferior to M257.

### Machinability

Although no tests have been made specifically to determine the machinability of APM products, it has been possible to observe some machining operations in the making of parts. For example, threads were machined on a few thousand M257 ¼-in. aircraft bolts. The threads were practically as smooth as those obtained with 2024-T4 stock and there was no trouble with tool wear. Customers who do extensive machining, including one who carries out screw machine operations, report that M257 machines satisfactorily and without unusual tool wear.

**TABLE 4—TOTAL CREEP**

| | Total Creep | Stress, psi 2024-T4 | 2618-T61 | X2219-T6 | M257 | M276 |
|---|---|---|---|---|---|---|
| 400 F | 0.1% in 1 hr | 20,000 | 26,000 | 19,000 | — | — |
| | 10 " | 14,000 | 22,000 | — | — | — |
| | 100 " | — | 19,000 | — | — | — |
| | 0.2% in 1 hr | 24,000 | 27,000 | 23,000 | 15,000 | 21,000 |
| | 10 " | 20,000 | 23,500 | 19,000 | 14,000 | 20,000 |
| | 100 " | 14,000 | 20,000 | — | — | — |
| | 0.5% in 1 hr | — | 28,000 | 27,000 | 17,500 | 25,000 |
| | 10 " | 24,000 | 24,500 | 23,000 | 16,500 | 23,000 |
| | 100 " | 19,000 | 21,000 | 20,000 | 15,000 | 21,000 |
| | 1000 " | 13,000 | 18,500 | — | — | 19,000 |
| | 1.0% in 1 hr | — | 29,000 | 29,000 | 18,000 | — |
| | 10 " | — | 25,500 | 26,000 | 17,000 | 24,000 |
| | 100 " | 21,000 | 21,500 | 24,000 | 16,000 | 22,000 |
| | 1000 " | 15,000 | 19,000 | 23,000 | — | 20,000 |
| 600 F | 0.1% in 1 hr | 3700 | 6500 | 9000 | — | 12,000 |
| | 10 " | — | 4000 | 7500 | — | — |
| | 0.2% in 1 hr | 5500 | 7000 | 10,500 | 11,000 | 14,000 |
| | 10 " | 3300 | 6000 | 8500 | 10,500 | 12,000 |
| | 100 " | 1800 | 3000 | 6700 | — | — |
| | 0.5% in 1 hr | 6100 | 8500 | 13,000 | 14,000 | — |
| | 10 " | 5000 | 6500 | 10,000 | 12,000 | 14,500 |
| | 100 " | 3000 | 4000 | 8000 | 10,000 | 13,000 |
| | 1000 " | — | — | — | — | 11,500 |
| | 0.1% in 1 hr | — | 9000 | — | — | — |
| | 10 " | 5500 | 7000 | 11,000 | 12,500 | — |
| | 100 " | 3600 | 4500 | 9000 | 11,000 | — |
| | 1000 " | — | 2500 | — | — | — |

**TABLE 5—PHYSICAL PROPERTIES**

| Alloy | Density, lb/cu in. at 68 F | Elec Cond at 77 F | Thermal Cond at 77 F[1] | Mod of Elast, psi[2] |
|---|---|---|---|---|
| M257 | 0.099 | 51 | 0.38 | $10.6 \times 10^6$ |
| M276 | 0.100 | 40 | 0.30 | $11.4 \times 10^6$ |
| 2024-T4 | 0.100 | 30 | 0.29 | $10.6 \times 10^6$ |
| X2219-T6 | 0.102 | 33 | 0.25 | — |
| 2618-T61 | 0.100 | 40 | 0.30 | $10.6 \times 10^6$ (A) |

[1] *B. T. U. per square foot per second for a temperature gradient of 1 F per inch.*
[2] *Average in tension and compression.*
*(A) Estimated from 2014, 2018, and 2024.*

## Joining

M257 can be joined by welding and by mechanical means. Tests indicate that welding methods involving a combination of heat and pressure hold more promise than fusion methods involving use of filler metal. Flash welding has given high strength joints at room and elevated temperatures as shown in Table 8. In fact, some of the flash-welded specimens broke in the parent metal instead of the weld. Spot welding has been used in preliminary tests for assembling M257 sheet parts with partial success.

In fusion methods involving fillers there is some porosity. Even if porosity were eliminated, the joint would be no stronger than the filler. Since all available filler alloys are weaker than M257 at elevated temperatures, fusion welds do not appear promising for use in highly stressed regions at elevated temperatures. M257 flows very sluggishly, if at all, and cannot to be used as filler metal.

M257 sheet has also been joined by mechanical means, such as by rivets, screws and bolts. Tests are still in progress, but it is already clear that M257 rivets have higher shear strengths at 600 and 800 F than alloy 2117 rivets as shown in Table 9. The shear strength of M257 machine screws is slightly lower than that of 2024-T4 at 600 F after ½ hr, but it is expected that the reverse will be true after longer times at 600 F and at higher temperatures.

**TABLE 6—AVERAGE COEFFICIENT OF THERMAL EXPANSION PER DEGREE FAHRENHEIT**

| | Temperature Range, F | | | | |
|---|---|---|---|---|---|
| Alloy | 68–212 | 68–392 | 68–572 | 68–752 | 68–842 |
| M257 | $11.8 \times 10^{-6}$ | $12.4 \times 10^{-6}$ | $12.9 \times 10^{-6}$ | $13.4 \times 10^{-6}$ | $13.6 \times 10^{-6}$ |
| M276* | 11.5 | 12.0 | 12.5 | — | — |
| 2024-T4 | 12.9 | 13.3 | 13.7 | — | — |
| X2219-T6 | 12.4 | 13.0 | — | — | — |
| 2618-T61 | 12.3 | 12.7 | — | — | — |

* *Estimated.*

**TABLE 7—TENSILE PROPERTIES OF M257 SHEET**

| Temp, F | Direction | Ten Str, psi | Yld Str 2% Offset, psi | Elong in 2 in, % |
|---|---|---|---|---|
| Room | With-Grain | 41,000 | 34,000 | 8.5 |
| Room | Cross-Grain | 43,000 | 36,000 | 8.0 |
| 600 | With-Grain | 22,500 | — | 7.5 |

**TABLE 8—TENSILE PROPERTI ES OF FLASH-WELDED M257¼-IN. THICK PLATE**

| Temp, F | Ten Str, psi | Yld Str 0.27 offset, psi | Elong in 2 in., % |
|---|---|---|---|
| Room | 36,000 | 28,000 | 5.5 |
| 600 | 19,700 | 16,100 | 7.5 |
| 800 | 11,900 | 10,500 | 3.5 |

**TABLE 9—SHEAR STRENGTH OF FASTENERS**

| Type of Fastener | Test Conditions | | Shear Strength, psi | | |
|---|---|---|---|---|---|
| | Temp, F | Time, Hr | M257 | 2117-T4 | 2024-T4 |
| 5/16 x 3/8 Std. Universal Head Rivet | Room | — | 23,000 | 35,000 | — |
| | 600 | ½ | 10,500 | 8500 | — |
| | 600 | 6 | — | 7000 | — |
| | 600 | 24 | — | 5500 | — |
| | 800 | ½ | 7400 | 2400 | — |
| No. 10-32 x ½" slotted fillister | Room | — | 26,000 | — | 47,000 |
| Head Machine Screw | 600 | ½ | 15,000 | — | 17,000 |
| | 800 | ½ | 10,000 | — | — |

*N. B. test was in single shear using lap joint in .091-in. sheet.*

## Plating and anodizing

APM products made from M257 and M276 can be electroplated. For example, 0.001-in. thick layers of hard chromium have been applied to the bore of M257 pneumatic cylinders and to specimens for General Motors scuffing tests. Silver plate has also been applied to APM products.

Alumilite hard coatings can be applied to M257 and M276. Most of the work has been done with M257 and application of this coating is commercially feasible although it requires a higher voltage to anodize M257 than conventional alloys. Alumilite 226 hard coating has been applied to M257 scuffing test specimens and to the bores of M257 pneumatic cylinders. Abrasion resistance of the coating on M257 compares favorably with that on conventional 1100 alloy.

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1. Swiss patents 250118 and 259878.
2. E. Gregory and N. J. Grant, "Aluminum Powder Products Compared," *Iron Age*, Dec 25, 1952, p. 69.
3. John P. Lyle, Jr., "Excellent Products of Aluminum Powder Metallurgy", *Metal Progress*, Dec 1952, p. 109.
4. E. Gregory and N. J. Grant, "High Temperature Strength of Wrought Aluminum Powder Products", *Journal of Metals*, Feb 1954, p. 247.
5. E. H. Dix, Jr., "Aluminum Alloys for Elevated Temperature Service", *Aeronautical Sciences*, Jan 1956, p. 40.

**Broaching rings** *used by aircraft industry to strip chips from broach and eliminate burr on edge of housing.*

*(Amplex Div., Chrysler Corp.)*

*How large a part can be produced by powder metallurgy? Examples in this article show that shapes up to about 22 in. in diameter are now being successfully made from a variety of metals and carbides.*

# Large Metal Powder Parts

**by John L. Everhart,**
*Technical Editor,*
*Materials & Methods*

■ A number of elements must be considered in deciding how large a part can be produced by powder metallurgy. Such factors as wall friction, internal friction and differences in pressure requirements for various powder compositions can be overcome generally by increases in press capacity. Production rate, however, can be the determining influence in deciding whether the metal powder part can compete with parts produced by other methods.

Many large bushings of the so-called oilless bearing type are produced on relatively low speed hydraulic presses. This increases the part cost, but no other method of production is available, and, therefore, low speed production is economically practical.

On the other hand, parts which compete with die castings, forgings, etc., must be produced at relatively low cost or much of the advantage of the metal powder process is lost. Development of large presses which can operate at reasonable speeds has opened the field for the production of parts of considerably larger cross-sections than are usually considered practical, a field which is expanding rapidly.

Large metal powder parts can be divided into two groups: 1) those which compete primarily on a cost basis, and 2) those which, because of unique characteristics or the use of high cost materials, can compete regardless of cost.

## Structural parts

Although structural parts can retain self-lubricating and other properties which are unique, they must compete primarily on a cost basis. Using the projected area equivalent to that of a 2-in. diameter circle as an arbitrary line of demarcation between small and large parts, large metal powder parts are in production from brass, bronze, iron-copper alloys, iron impregnated with copper, iron, carbon steel and prealloyed steel powders. Parts 10, 12, 18 and 22 in. in dia are in regular production. In some cases these are high density parts; in others, lower density parts have been produced to be oil-impregnated.

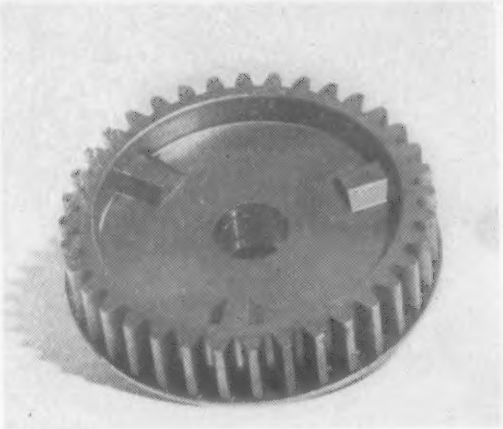
Ability to compete is closely associated with production rate in these parts. Rates vary with the size and type of part and the type of pressing equipment.

There are three basic considerations that always enter into the speed at which any part can be compacted. These three factors are 1) size, shape and/or wall thickness of the part, 2) speed of the press to be used and 3) flow characteristics of the powder which are affected by type and amount of lubricant required. Each of the basic considerations listed has its own variables. For instance, the part may be very complex in shape and require multiple motion both to compact and eject. In some cases the parts are such that they have to be individually handled to prevent breakage.

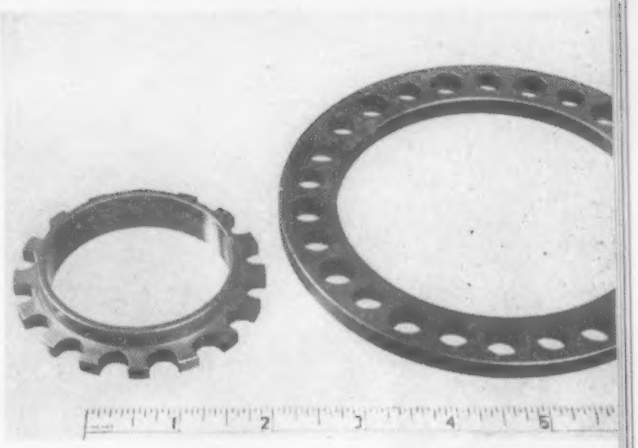
The speed of the press depends first upon its size and type. Types of presses vary; that is, there are different types of mechanical and hydraulic presses. The design or type of the press has a direct bearing on its speed. The type of feeder used and its relation to the cycle are very important when determining how fast a part can be compacted. Assuming that the density requirement of the part dictated the application of 30 tsi pressure, a ½-in. diameter part can be produced readily on a 10-ton press while a 2-in. diameter part will require a press of about 100 tons capacity. The speed of the smaller press would be higher than that of the larger press.

Another factor in production rate is the rate at which a uniform filling of the die can be obtained. Uniform fill is extremely important because the amount of powder from which the part is pressed controls both dimensions and density and must be held within 1% of optimum to yield parts within tolerance limits.

Another determining factor on press capacity is composition of

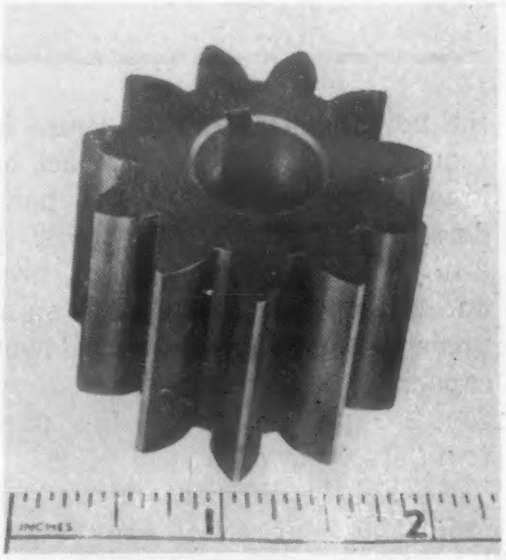


**Lawn mower gear** replaced an assembly of three parts, including a bushing which was eliminated because of the self-lubricating feature of the metal powder part. Gear hardened by heat treatment.
**Size:** 3½ in. o. d. (approx).
**Material:** 0.25-1.0% carbon, balance iron powder.
*(Beemer Engineering Co. and Amplex Div., Chrysler Corp.)*

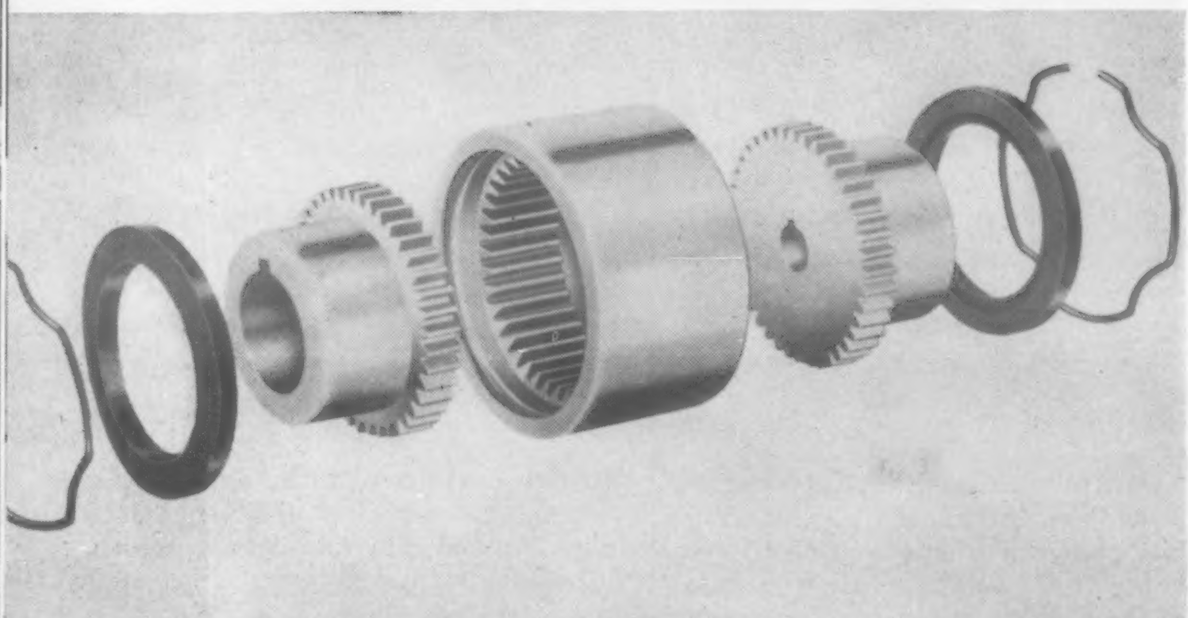


**Bronze retainer and sprocket** used in automotive clutch for smooth operation and good lubrication properties.
**Size:** Retainer 4½ in. o. d., 3¼ in. i. d.; sprocket 2½ o. d. (approx).
**Material:** 90 copper-10% tin (ASTM Type I, Class A).
*(Keystone Carbon Co.)*

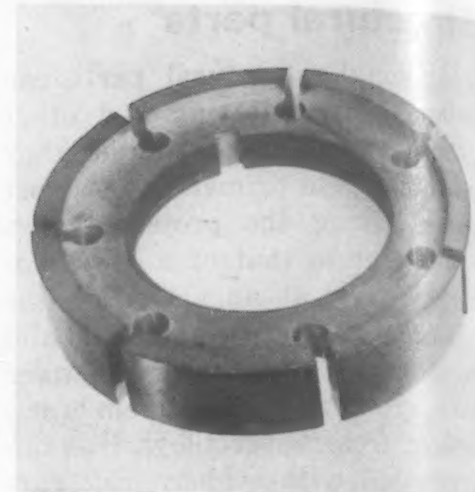
**Quadrant gear** for use in domestic washing machines is required to withstand high impact loads. The finished part is made by a simple pressing operation followed by combined sintering and infiltration instead of the expensive machining and hobbing usually required to produce a gear of this type.
**Size:** 2½ in. deep (approx).
**Material:** Iron powder infiltrated with copper.
*(National-U. S. Radiator Corp.)*



**Hydraulic pump gear.** Production operations include pressing, sintering, two coining and resintering steps and quenching for hardening. After heat treatment, the gear has a hardness of Rockwell C50 min. Produced at a rate of 200 parts per hr, this gear costs 20% less than conventional gear used previously.
**Size:** 2 in. dia (approx).
**Material:** Nickel-molybdenum steel. 0.30 carbon, 1.85 nickel, 0.25 molybdenum, 0.50 manganese and 0.25% silicon.
*(Keystone Carbon Co.)*



**Flexible gear coupling** designed for transmission of medium-to-heavy loads at high speeds. By producing this coupling from powder, the manufacturer has been able to offer the assembly at a saving of 40% over a comparable coupling made by conventional machining methods.
**Size:** Internal gear section 3¼ in. o. d., 1-13/16 in. long; external gear sections 2 in. dia, 1⅜ in. long.
**Material:** Steel powder.
*(Beemer Engineering Co. and Amplex Div., Chrysler Corp.)*



**Automotive transmission ring** produced from powder with hole and slot dimensions held to specified limits saves expensive drilling and machining operations.
**Size:** 3 in. dia (approx).
**Material:** Iron powder.
*(National-U. S. Radiator Corp.)*

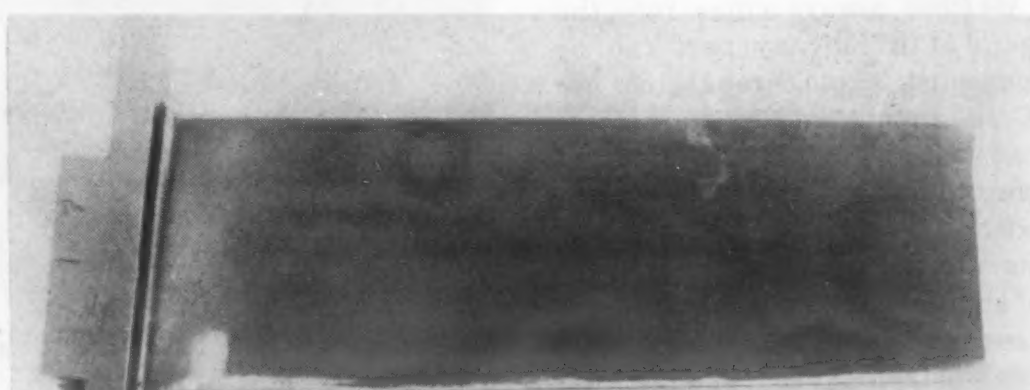
the powder mix. Less pressure is required to produce a compact of given density from bronze powders than from steel powders. A 2-in. diameter part can be produced from bronze powder on a press having considerably lower capacity than would be required for the production of the part from steel powder.

A slightly different method of indicating this effect can be obtained from the announcement by Amplex that their 3000-ton press can produce parts having the following projected areas: 200 sq in. for bronze, 150 sq in. for 75 copper-25% iron alloys and 100 sq in. for steel.

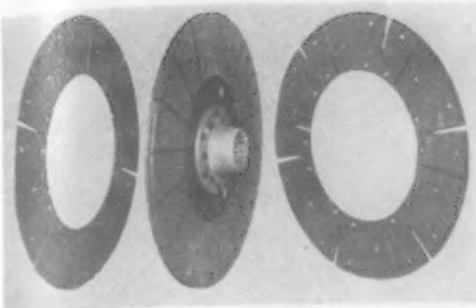
Quite a number of large parts are now in production, and the examples given indicate possibilities in this field.

## Parts having unique properties

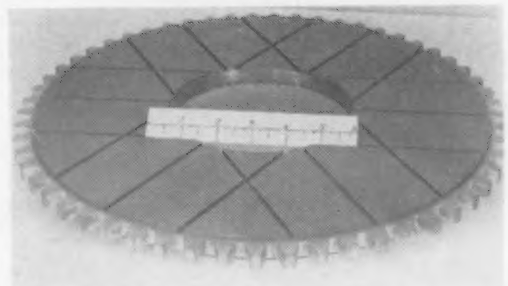
Parts which do not have to compete strictly on an economic basis include the large self-lubricating bearings, friction materials and cemented carbides. This does not imply that cost is not a considerable factor in selection but in-



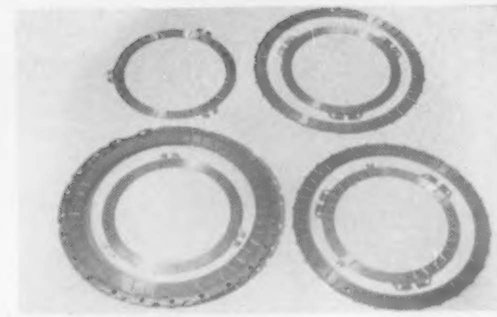
**Compressor blade** for J-35 engine.
**Size:** 4½ in. long (approx).
**Material:** Infiltrated steel.
*(American Sinteel Corp.)*



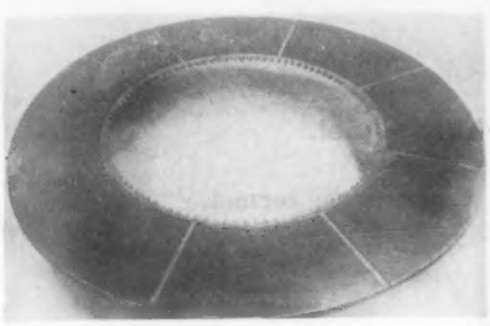
**Clutch plate and facings** used in clutches of off-the-highway crawler type equipment.
Size: Facing 15 in. o. d., 8 in. i. d., 3/16 in. thick; clutch plate 15 in. dia.
Material: Mixture of metal and non-metal powders. *(S. K. Wellman Co.)*



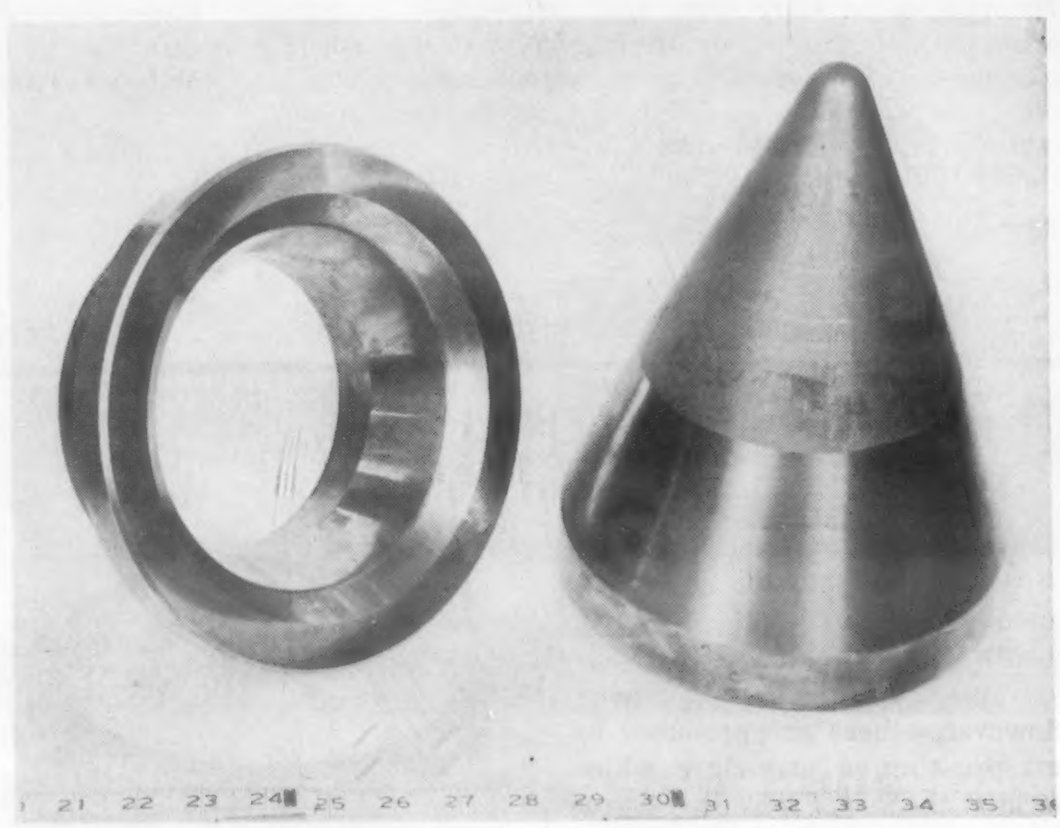
**Clutch plate** used on off-the-highway crawler type equipment has grooving cut through friction face for scavaging effect to remove wear particles and foreign deposits.
Size: 15 in. dia (approx).
Material: Mixture of metal and non-metal powders.
*(S. K. Wellman Co.)*



**Heavy duty automatic transmission clutch disks** are grooved to disperse the cooling oil across the working surfaces.
Size: 12½ to 18 in. dia.
Material: Mixture of metal and non-metal powders.
*(S. K. Wellman Co.)*



**Internal splined sandwich type disk** in which friction material is bonded directly to steel structural member.
Size: 36 in. o. d.
Material: Mixture of metal and non-metal powders.
*(S. K. Wellman Co.)*



**Cone and ring** for large regulator valve used in controlling hot (1100 F) high velocity combustion gases containing 20% abrasive solids.
Size: Cone 7 in. dia, 11 in. long; ring 8¾ in. o. d., 4 in. i. d.
Material: Cemented tungsten carbide compositions.
*(Kennametal Inc.)*

dicates that unique properties generally control.

Large size self-lubricating bushings and bearings are made from copper or iron powder base materials with various other alloying elements. These products are sufficiently low in density to be quite porous, the pores being oil-filled. Bushings up to 20 in. diameter and 200 pounds in weight have been produced.

### Friction materials

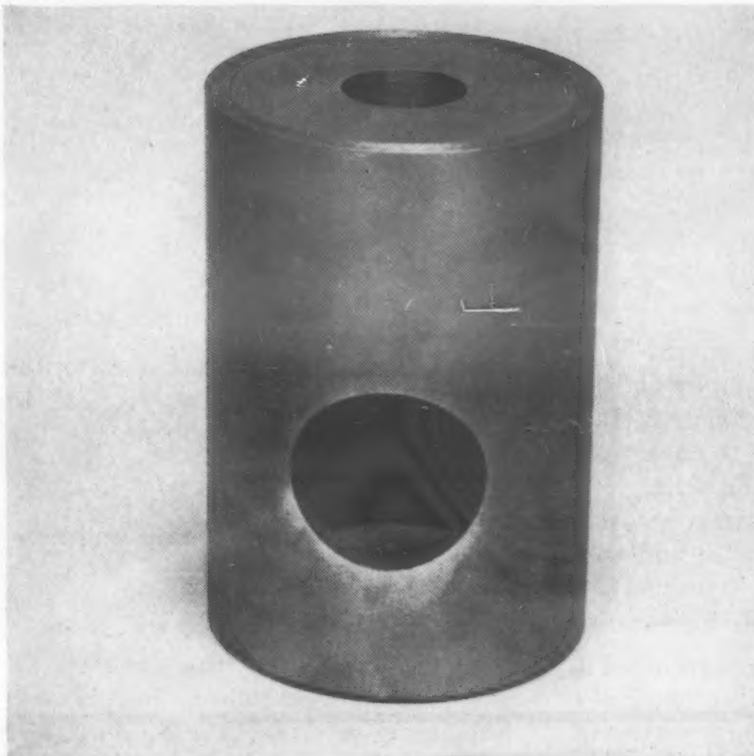
Friction materials are produced from various mixtures of copper, iron, tin, lead, graphite and silica powders by procedures common to other metal powder parts. In friction materials, however, performance rather than cost is the criterion since these materials are generally higher priced than competing materials such as asbestos.

The size range of these materials is large. Friction faces have diameters up to several feet; thickness of the compact may range from ¼ to 1 in. Typical presses used in this operation are rated at 350 tons capable of handling compacts up to 24 sq in., 1200 tons handling 90 sq in. and 3000 tons handling areas up to 230 sq in.

Metal powder friction materials are used in many automotive and industrial applications. These include tractor steering clutches, aircraft landing brakes, automatic transmissions, machine tool clutches, automotive brakes and clutches.

### Cemented carbides

Cemented carbide parts are pro-

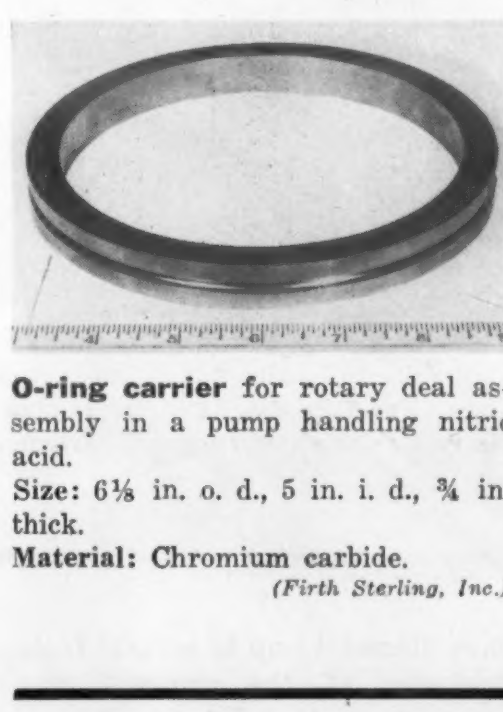


**Throttle valve body liner** used for pressure control of molten coal and oil mixture at 1400 to 1500 F, 6000 psig pressure drop to 2500 psig, hydrogen atmosphere.
**Size:** 3½ in. o. d., 7 in. high, 1½ in. hole machined into side by method X process.
**Material:** Chromium carbide. *(Firth Sterling, Inc.)*

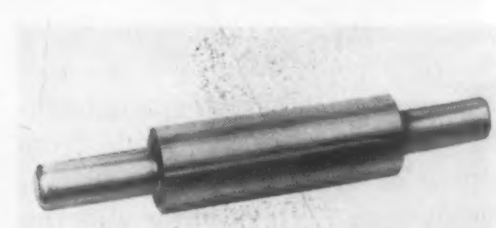
**Experimental turbine wheel.**
**Size:** Up to 8 in. dia.
**Material:** Titanium carbide base cermet. *(Schwarzkopf Development Corp.)*

duced from tungsten, titanium, chromium, tantalum and similar carbides cemented with nickel or cobalt. Some parts are made by conventional powder methods. However, others are produced by hot pressing, a procedure which permits the use of lower pressures than are required at room temperature.

Among properties of the cemented carbides which lead to their application in large structural parts are high modulus of elasticity, compressive strength, strength at elevated temperatures, corrosion resistance and abrasion resistance.



**O-ring carrier** for rotary deal assembly in a pump handling nitric acid.
**Size:** 6⅛ in. o. d., 5 in. i. d., ¾ in. thick.
**Material:** Chromium carbide. *(Firth Sterling, Inc.)*



**Solid roll** for cold rolling strip steel provides better surface finish on the strip than obtained with conventional steel rolls.
**Size:** 2½ in. dia, 8½ in. face, 16½ in. long.
**Material:** Cemented tungsten carbide compositions. *(Kennametal Inc.)*

***Acknowledgment***

The assistance of the following organizations in the preparation of this article is gratefully acknowledged.

American Sinteel Corp.
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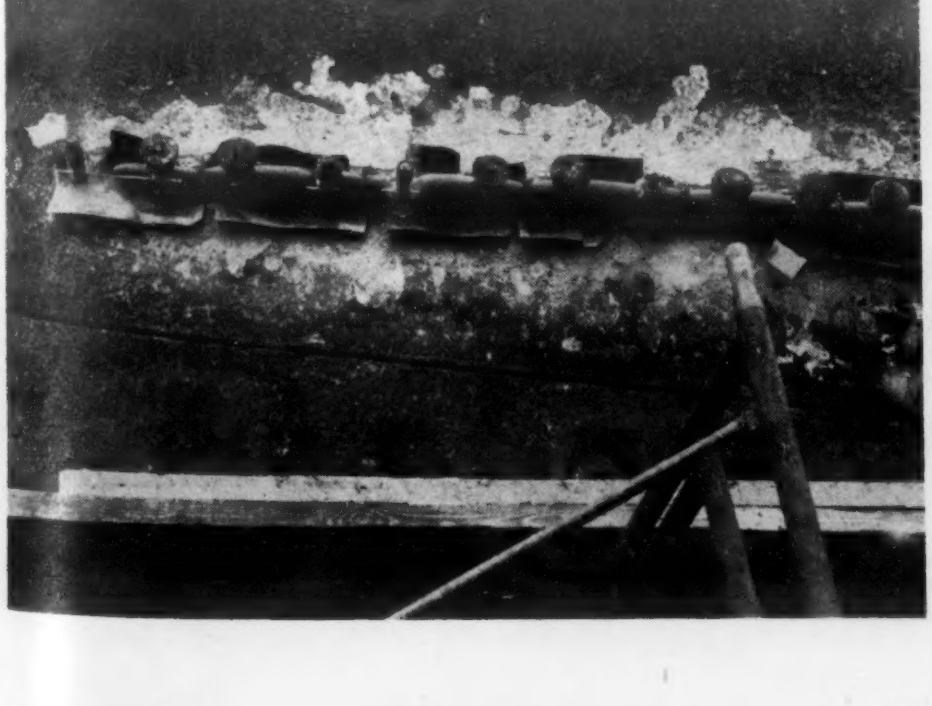
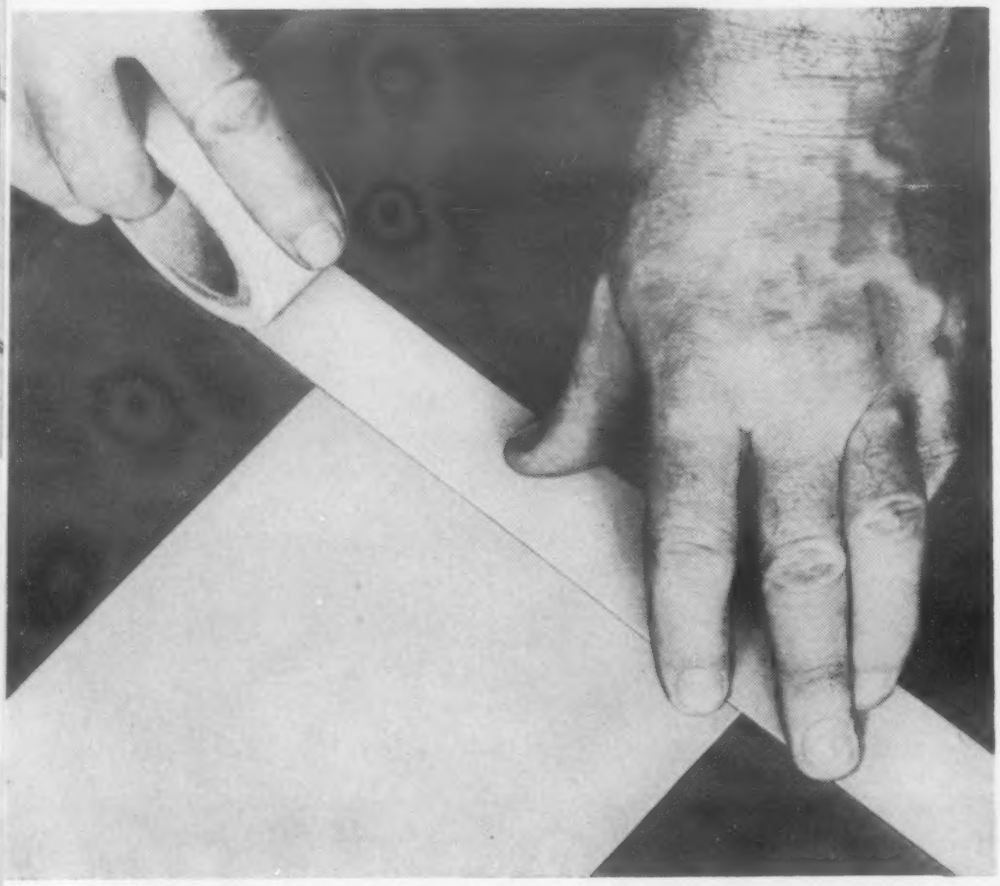
Kennametal Inc.
Keystone Carbon Co.
National-U. S. Radiator Corp.
New Jersey Zinc Co.
The Presmet Corp.
F. J. Stokes Machine Co.
Schwarzkopf Development Corp.
U. S. Graphite Co.
S. K. Wellman Co.

# Magnesium protects ship hulls



After 13 months at sea the SS Marine Chemist shows the results of good cathodic protection using strings of magnesium anodes on each side. Close-up view of anode string shows good uniformity of magnesium corrosion. Uniformity was promoted by using cement in stud bolt recesses.

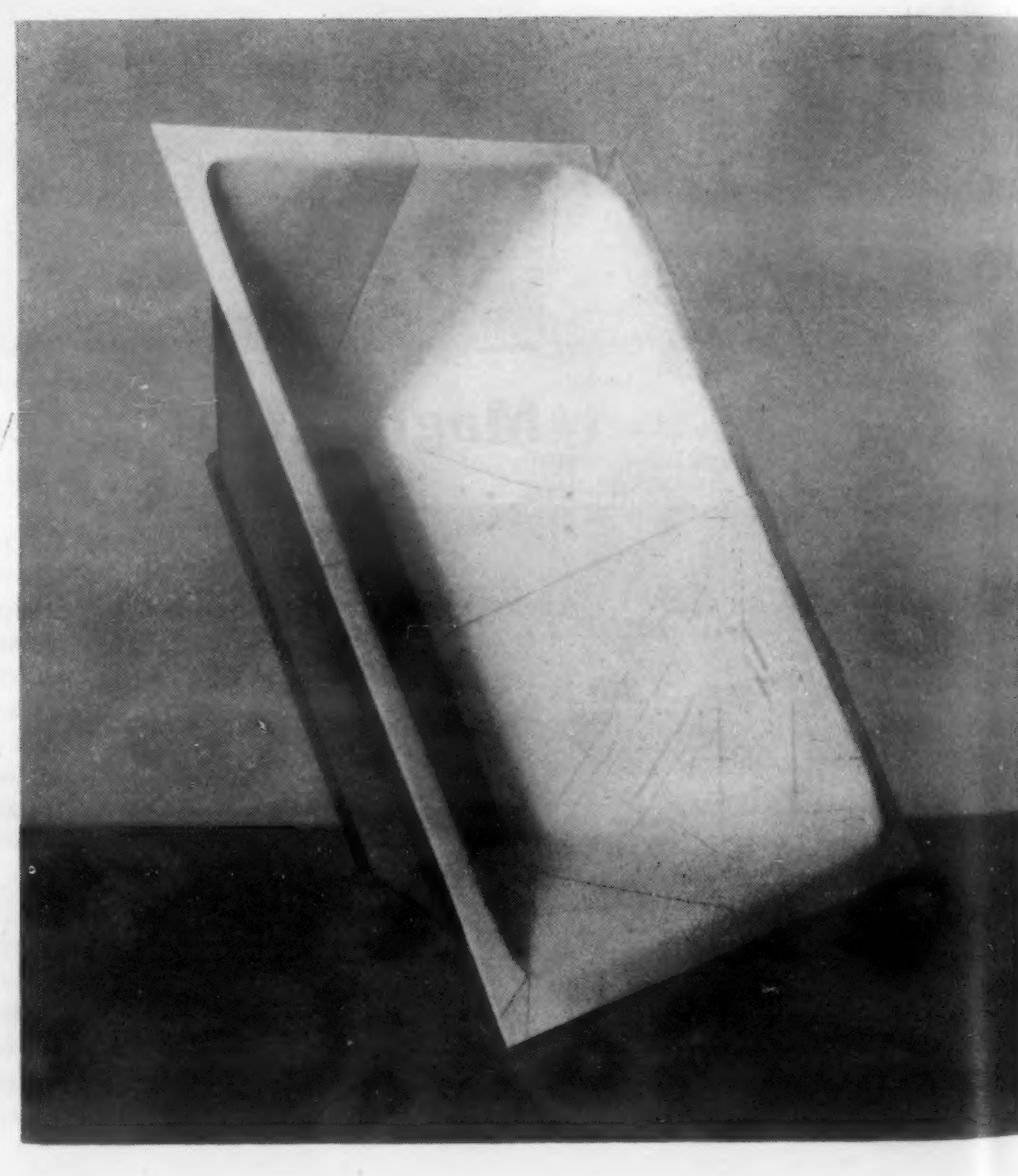
# Bonding Qualities of Teflon



**Teflon tape,** *treated and with adhesive applied, adheres to a variety of materials, forming a strong bond.*

*(U. S. Gasket Co.)*

*Here are the initial facts on a new treatment which permits Teflon to be cemented to other materials. Tensile shear and peel strengths of bonds are said to be the best yet attained.*



**Hopper is lined** *with 1/16-in. thick Teflon sheet. The hopper is used by American Cyanamid to feed titanium oxide. Teflon provides a smooth, slippery surface preventing sticking of the material to the hopper.*

*(U. S. Gasket Co.)*

# Improved by New Treatment

■ Teflon, in section thicknesses down to 0.005 in. or less, can now be bonded to virtually any cementable material with conventional adhesives. Tensile shear strengths of bonds are on the order of 114 to 354 psi, depending on the adhesive used and the material to which Teflon is bonded. Accompanying tables list strengths of bonds obtainable using various adhesives to bond Teflon to several materials.

Key to the development is a new treatment which chemically etches Teflon surfaces permitting adhesives to form a mechanical bond. The treatment is essentially a one-step process, consisting of immersion of Teflon in a bath for a specified period, followed by a quench in cold water.

### Availability and applications

Developed by Du Pont, details of the treatment are available to processors of Teflon. At present, U. S. Gasket Co. is producing cementable Teflon tape in thicknesses of 5 to 60 mils, and sheets in thicknesses of 1/32- and 1/16-in.

The material is expected to find use wherever the characteristics of Teflon, such as anti-stick properties, chemical resistance, and toughness are required on the surface of another material. Such applications include frictionless facings for conveyor and packaging machine guide rails; liners and coverings for tanks, pipe and ducts; facings for valves and machine parts; and insulation for electric motor windings and electronic coils.

### The process

The bath consists of metallic sodium dissolved in liquid anhydrous ammonia. Maximum recommended strength of the solution is about 1%. When sodium is added to liquid ammonia a characteristic dark blue solution is obtained. Mild stirring will insure complete solution of the sodium before immersing the Teflon. During all operations moisture must be excluded from the processing tank to prevent a poor bonding surface on the resultant product.

Volume of solution required depends on the amount of Teflon to be treated. A bath of 15 gm sodium in 1500 gm liquid ammonia is sufficient for hand dipping 30 ft of 0.010-in. thick, 8-in. wide tape. Immersion time in the bath ranges from 1 to 5 sec.

As Teflon emerges from the bath, residual ammonia volatilizes upon exposure to air. However, residual sodium hydroxide and treating solution should be removed by a cold water quench. Teflon is then removed from the cold water bath and dried. After drying, treated Teflon has a dull dark brown color.

### Reference

*Information Bulletin No. X-75, Teflon, Tetrafluoroethylene Resin, Treatment for Bonding, Polychemicals Dept., E. I. du Pont de Nemours & Co. (Inc.).*

**PEEL STRENGTH OF TREATED TEFLON BONDED TO SEVERAL MATERIALS, LB/IN.**

| Adhesives | Teflon | Aluminum | Steel | Wood | Rubber | Neoprene |
|---|---|---|---|---|---|---|
| A | 40.5 | 45.0 | 62.8 | 37.8 | 8.0 | 10.6 |
| B | 30.2 | 51.2 | 58.7 | 41.3 | 12.4 | 10.2 |
| C | 31.7 | 45.5 | 49.8 | 35.5 | 3.8 | 10.8 |

*Adhesives are: A—Bonding Agent R-313, Carl H. Biggs Co.*
*B—M-611, Rubber & Asbestos Corp.*
*C—NT-285, Miracle Adhesive Corp.*

## *Handling Precautions*

Metallic sodium and liquid ammonia are hazardous chemicals, but can be handled safely if suitable precautions and recommended handling techniques are followed. The following safety data sheets for both sodium and anhydrous ammonia are available from the Manufacturing Chemists' Association Inc., 1625 Eye St. N.W., Washington 6, D.C.

*Chemical Safety Data Sheet SD-8*—Properties and Essential Information for Safe Handling and Use of Anhydrous Ammonia

*Chemical Safety Data Sheet SD-47*—Properties and Essential Information for Safe Handling and Use of Sodium, Sodium Metal and Metallic Sodium

**BOND STRENGTH OF SODIUM-TREATED TEFLON**

| Teflon Bonded to: | Adhesive | Ten Str in Shear, psi[a] |
|---|---|---|
| Aluminum | A-6 Epoxy Activator E[b] | 114 |
| Teflon | A-6 Epoxy, Activator E[c] | 114 |
| | A-6 Epoxy, Activator A[e] | 71.3 (at 212 F) |
| Wood (Oak) | A-6 Epoxy, Activator A[e] | 210-270 |
| | A-1 Epoxy, Activator A[e] | 225-290 |
| | Bonding Agent R-313[d] | 235-245 |
| | Penacolite Resin Adhesive G-1124A[e] | 210-290 |
| | Miracle Adhesive W-799[f] | 220-270 |
| | Epon Adhesive VI[g] | 135-240 |
| Mild Steel | Bonding Agent R-313 | 315-354 |

[a] *Room temperature unless otherwise indicated.*
[b] *Tensile strength of butt joints are 676 psi.*
[c] *Armstrong Products Co.*
[d] *Carl H. Biggs Co.*
[e] *Koppers Co., Inc.*
[f] *Miracle Adhesive Corp.*
[g] *Shell Chemical Corp.*

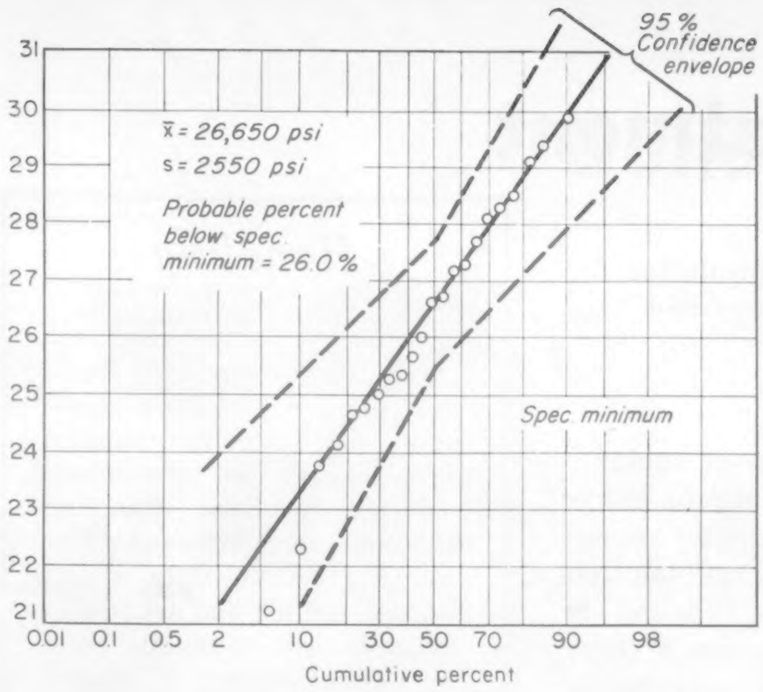



**Fig 1** *Distribution of tensile strength on arithmetic paper gives an accurate check on material performance.*

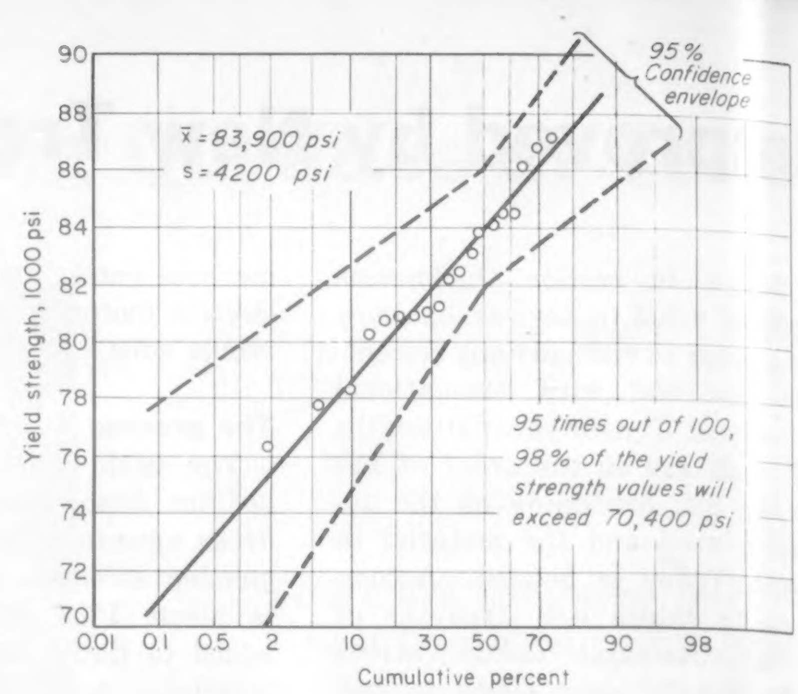



**Fig 2** *Distribution of yield strength forecasts minimum expected values for use in setting up specification limits.*

# How to Use Statistical Quality Control for Materials Selection

*If you are responsible for selecting or evaluating materials, statistical quality control methods can give you a firm basis for making your choice. These methods will allow you to 1) set up specification limits, 2) check material performance over a period of time, or 3) accurately check a supplier's claims concerning his products.*

**by D. Peckner**
*Materials Engineering Dept., Westinghouse Electric Corp.*

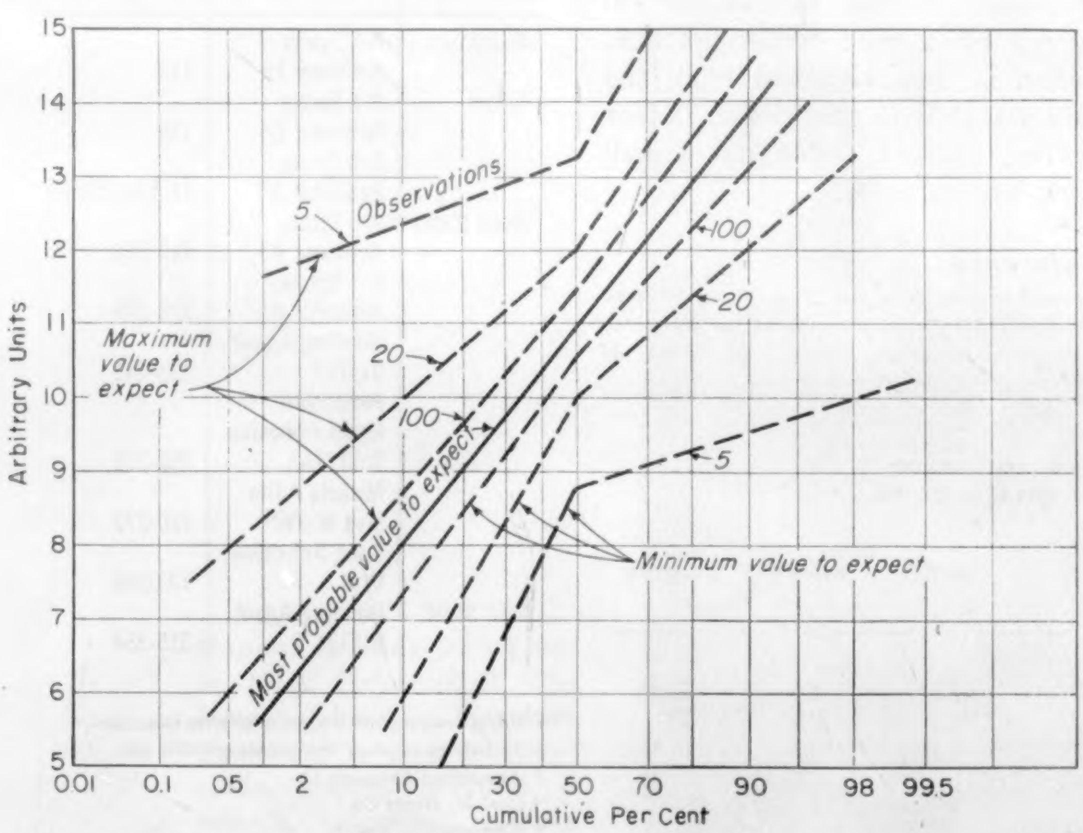



**Fig 3** *Reliability increases as the number of observations increase. A similar effect results when the confidence level is decreased.*

■ Application of statistical quality control principles is made simple by the use of arithmetic probability paper. Plotting data on this type of paper condenses the 20 or 30 numbers which may extend over a wide range to two numbers—the arithmetic mean ($\overline{X}$) and the estimate of the standard deviation (s).

For most engineering purposes, knowledge of the value of the arithmetic mean ($\overline{X}$) and the estimate of standard deviation (s) will supply all necessary information required before using material on which the observations are based. Since 50% of the total number of observations will be above, and 50% below the mean, the intercept of the ordinate and 50% abscissa can be read to obtain $\overline{X}$ directly.

Another well-known property of the normal distribution is used to obtain s. On arithmetic probability paper, the area under the curve between the 16% and 84% abscissa is represented by the value of $\overline{X} \pm$ s. Therefore, determining the value of the intercept of the 84% abscissa and subtract-

ing $\overline{X}$ will give the value of s directly. Similarly, subtracting the value of the intercept of the 16% abscissa from $\overline{X}$ will also determine the value of s.

### Checking material performance

Fig 1 demonstrates the use of arithmetic probability paper to check performance of a material. An aluminum-13% silicon alloy (13 alloy) was being poured in the permanent mold shop. The material is required to have a minimum tensile strength of 25,000 psi. Tensile samples were poured over a period of three months and data obtained were plotted (see Fig 1). Several facts were developed from this curve:

1. The average ($\overline{X}$) tensile strength to be expected is 26,650 psi.
2. By inspection, the intercept of the specification minimum (25,000 psi) and the curve indicates that 26% of the material will probably be below specification minimum.
3. The confidence envelope indicates that 95 times out of 100, as little as 7.5% of the material and as much as 45% of the material could be expected to exhibit tensile strengths below the specification minimum.

Recommendations were consequently made to the design engineer and appropriate measures were taken to correct his design information.

### Setting up specification limits

A new aluminum bronze alloy was needed for the permanent mold shop. A literature survey turned up a promising alloy but, as usual, only average mechanical properties were quoted. Since an arithmetic average gives no indication of the values at the extremes of a distribution, a more accurate estimate of mechanical properties was required.

By pouring tensile bars from several experimental heats, the minimum expected value of yield strength, tensile strength, elongation, etc. was forecast and incorporated into a specification. The probability plot for yield strength is shown in Fig 2.

## *The Confidence Envelope*

### Its significance

In both Fig 1 and 2, the reader will note that an "envelope" has been drawn around the curve representing test observations. The confidence level chosen and the confidence envelope associated with it are used to answer the question, "How reliable are the statements which have been made?"

It can be observed that two sets of similar observations on the same material, plotted on probability paper, will give rise to slightly different distributions. The use of a confidence envelope, which takes into account errors in the mean ($\overline{X}$) and estimate of the standard deviation (s), becomes a necessity if the interval within which a distribution lies is to be determined.

A choice usually must be made as to the "confidence" level desired. For most engineering purposes, the 95% confidence level is generally chosen. The degree of certainty associated with this confidence level will satisfy almost all of the requirements of the engineer.

One danger of using too high a confidence level (such as the 99% level) arises from the fact that in many engineering investigations a great many observations cannot be made. By sacrificing some degree of certainty it is possible to increase the practical utility of a statement of material properties. Fig 3 indicates how the degree of reliability increases with the number of observations. A similar change can be noted by decreasing the confidence level. Thus, the width of the confidence envelope decreases both as the sample size increases and the confidence level decreases.

### How to construct it

Drawing of the confidence envelope is done on the basis of the following facts:

1. The true arithmetic mean lies within the interval $\overline{X} \pm \frac{k\ s}{\sqrt{n}}$.
2. The true standard deviation lies within the interval $s \pm \frac{k\ s}{\sqrt{2n}}$.

The constant k depends on the number of observations and desired confidence level while n represents the number of observations. The accompanying table lists approximate values of k for different confidence levels and sample sizes.

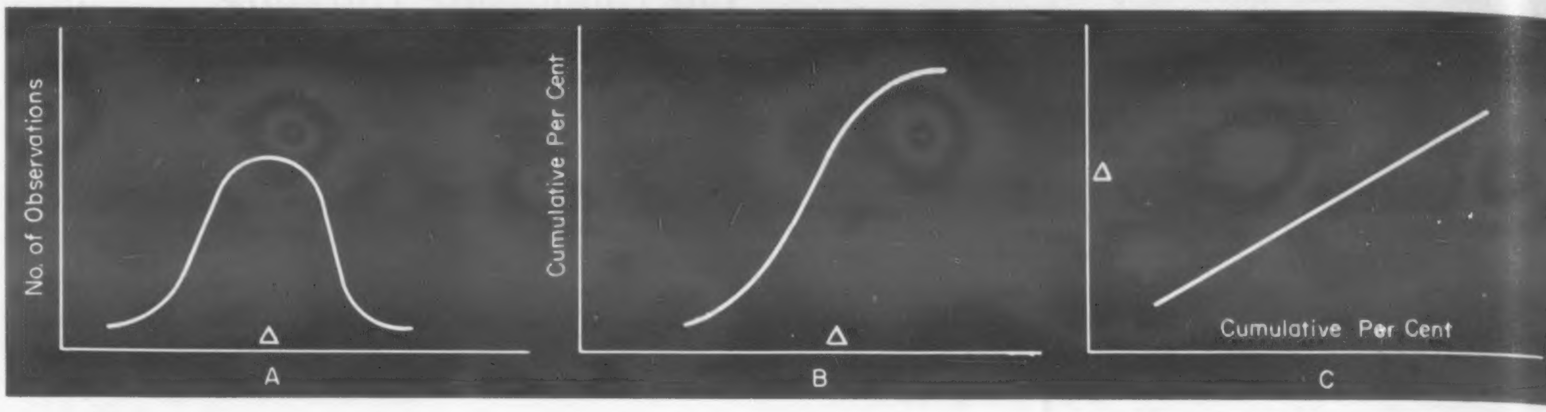
Using the values of $\overline{X}$ and s derived from Fig 1, the confidence envelope for these observations was derived as follows:

1. The arithmetic mean lies within the range $\pm \frac{k\ s}{\sqrt{n}}$. From Fig 1, we note that s = 2550 psi. From the accompanying table on the basis of a 95% confidence level and 22 observations, k = 2.06. Therefore, $\frac{k\ s}{\sqrt{n}} = \pm \frac{(2.06)\ (2550)}{\sqrt{22}} = \pm 1120$ psi.
2. The range of the estimate of the standard deviation $= \pm \frac{k\ s}{\sqrt{2n}}$. Since k and s remain the same, the interval is $\pm \frac{(2.06)\ (2550)}{\sqrt{44}} = \pm 790$ psi.

To construct the confidence envelope, at 50 cumulative per cent plot two points; one 1120 psi above and one below the curve. At 16 cumulative per cent and 84 cumulative per cent plot points 1910 psi (1120 psi + 790 psi) above and below the curve. Connecting the points produces the confidence envelope.

**FACTOR k FOR MULTIPLYING THE ESTIMATED STANDARD DEVIATIONS OF $\overline{X}$ AND s TO OBTAIN CONFIDENCE ENVELOPES**

| Probability Level, % | Sample Size | | | |
|---|---|---|---|---|
| | 10-15 | 16-20 | 21-30 | Very Large |
| 90 | 1.78 | 1.74 | 1.71 | 1.65 |
| 95 | 2.18 | 2.11 | 2.06 | 1.96 |
| 99 | 3.06 | 2.90 | 2.79 | 2.58 |




## What Is Probability Paper?

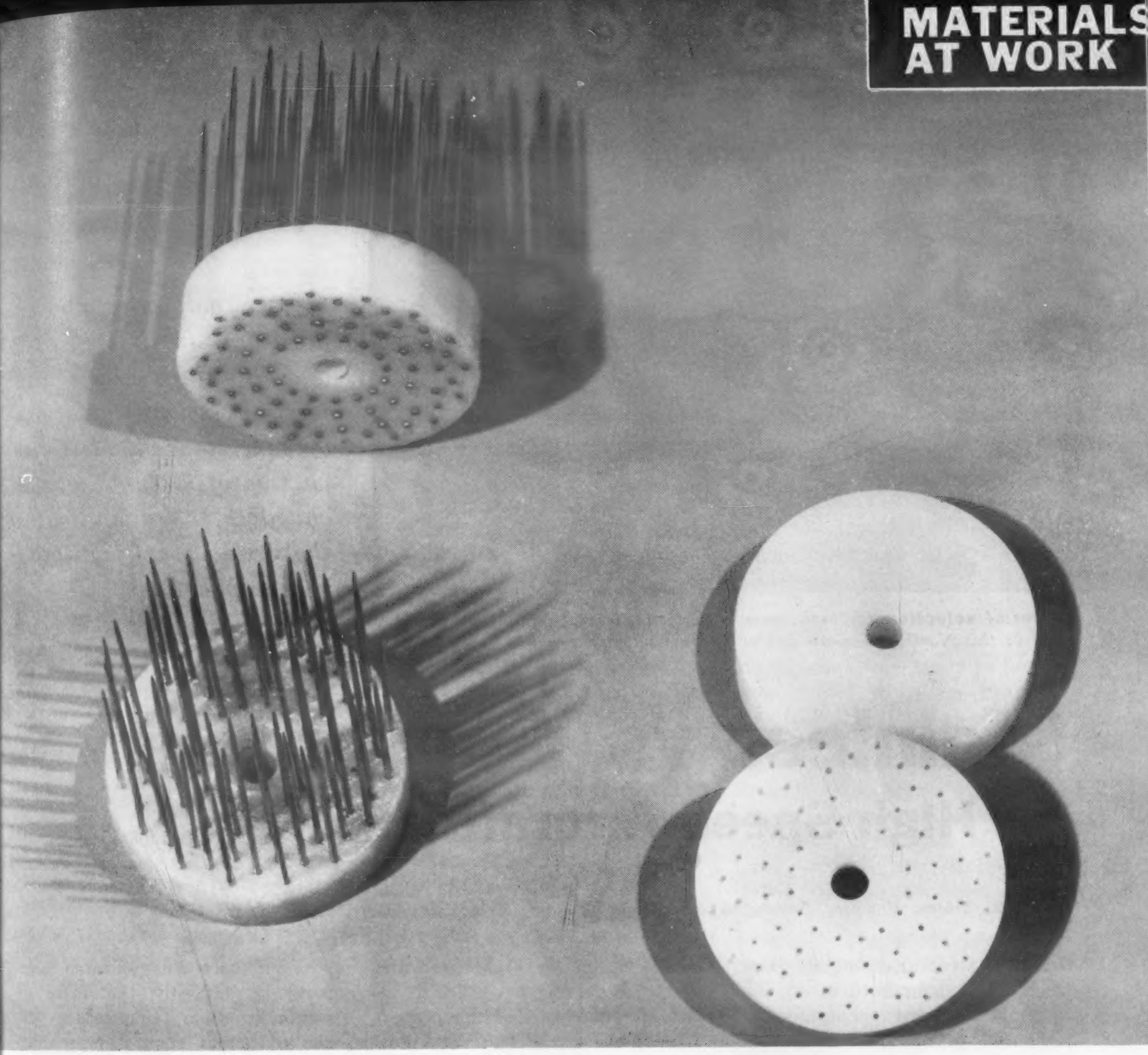
The development of arithmetic probability paper can be visualized as follows: Assume that A represents the standard normal distribution curve of a set of data, the familiar "bell-shaped" curve defined by $\phi$ (t) $= \frac{1}{\sqrt{2\pi}} e^{\frac{-t^2}{2}}$. Integrating $\phi$ (t) results in a curve similar to B on which is plotted the cumulative per cent of observations at or below a given value, against that value. If the abscissa of B is now stretched symmetrically about the 50% value, the curve becomes a straight line C, and the scale of the abscissa becomes a probability scale. Cumulative per cent is plotted on the probability scale since the probability curve represents the integral of the area under the normal probability curve. Cumulative percentages for varying numbers of observations are given in the accompanying table.

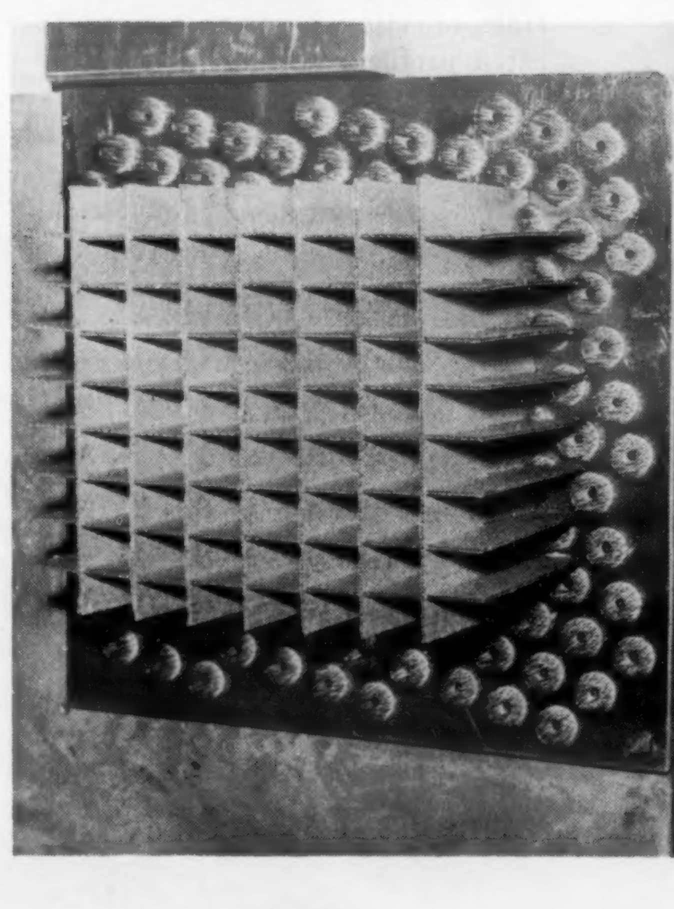
One major shortcoming of probability paper should be noted here. If the data do not fall on an approximately straight line when plotted on probability paper, this method of analysis cannot be used. Radical deviation from a straight line indicates a skewed distribution whereas the scale of the abscissa has been based on a normal distribution. The ease with which the arithmetic mean $(\overline{X})$ and the estimate of standard deviation (s) can be obtained sometimes leads to an artificial "fit" of a straight line to the data with the consequence that invalid data are obtained. If the data are skewed, then $\overline{X}$ and s must be calculated mathematically.

**CUMULATIVE PERCENTS CORRESPONDING TO VARIOUS SAMPLE SIZES**

| | Sample Size | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ob. No. | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 1 | 5 | 4.5 | 4.2 | 3.8 | 3.6 | 3.3 | 3.1 | 2.9 | 2.8 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 | 2.1 | 2.0 | 1.9 | 1.9 | 1.8 | 1.7 | 1.7 |
| 2 | 15 | 13.6 | 12.5 | 11.5 | 10.7 | 10.0 | 9.4 | 8.8 | 8.3 | 7.9 | 7.5 | 7.1 | 6.8 | 6.5 | 6.25 | 6.0 | 5.8 | 5.6 | 5.4 | 5.2 | 5.0 |
| 3 | 25 | 22.7 | 20.8 | 19.2 | 17.8 | 16.7 | 15.6 | 14.7 | 13.9 | 13.2 | 12.5 | 11.9 | 11.4 | 10.9 | 10.4 | 10.0 | 9.6 | 9.3 | 8.9 | 8.6 | 8.3 |
| 4 | 35 | 31.8 | 29.2 | 26.9 | 25.0 | 23.3 | 21.9 | 20.6 | 19.4 | 18.4 | 17.5 | 16.7 | 15.9 | 15.2 | 14.6 | 14.0 | 13.5 | 13.0 | 12.5 | 12.1 | 11.7 |
| 5 | 45 | 40.9 | 37.5 | 34.6 | 32.1 | 30.0 | 28.1 | 26.4 | 25.0 | 23.7 | 22.5 | 21.4 | 20.4 | 19.6 | 18.75 | 18.0 | 17.3 | 16.7 | 16.1 | 15.5 | 15.0 |
| 6 | 55 | 50.0 | 45.8 | 42.3 | 39.2 | 36.7 | 34.4 | 32.3 | 30.6 | 29.0 | 27.5 | 26.2 | 25.0 | 23.9 | 22.9 | 22.0 | 21.2 | 20.4 | 19.6 | 19.0 | 18.3 |
| 7 | 65 | 59.1 | 54.2 | 50.0 | 46.4 | 43.3 | 40.6 | 38.2 | 36.1 | 34.2 | 32.5 | 30.9 | 29.6 | 28.3 | 27.1 | 26.0 | 25.0 | 24.1 | 23.2 | 22.4 | 21.7 |
| 8 | 75 | 68.2 | 62.5 | 57.7 | 53.5 | 50.5 | 46.9 | 44.1 | 41.7 | 39.5 | 37.5 | 35.7 | 34.1 | 32.6 | 31.25 | 30.0 | 28.9 | 27.8 | 26.8 | 25.9 | 25.0 |
| 9 | 85 | 77.3 | 70.8 | 65.4 | 60.7 | 56.7 | 53.1 | 50.0 | 47.2 | 44.8 | 42.5 | 40.5 | 38.7 | 37.0 | 35.4 | 34.0 | 32.7 | 31.5 | 30.4 | 29.3 | 28.3 |
| 10 | 95 | 86.4 | 79.2 | 73.1 | 67.8 | 63.3 | 59.4 | 55.9 | 52.8 | 50.0 | 47.5 | 45.2 | 43.2 | 41.3 | 39.6 | 38.0 | 36.6 | 35.2 | 33.9 | 32.8 | 31.7 |
| 11 | | 95.5 | 87.5 | 80.8 | 75.0 | 70.0 | 65.6 | 61.8 | 58.4 | 55.3 | 52.5 | 50.0 | 47.7 | 45.7 | 43.75 | 42.0 | 40.4 | 38.9 | 37.5 | 36.2 | 35.0 |
| 12 | | | 95.8 | 88.5 | 82.1 | 76.7 | 71.9 | 67.7 | 63.9 | 60.6 | 57.5 | 54.7 | 52.2 | 50.0 | 47.9 | 46.0 | 44.2 | 42.6 | 41.1 | 39.7 | 38.3 |
| 13 | | | | 96.2 | 89.2 | 83.3 | 78.1 | 73.6 | 69.4 | 65.8 | 62.5 | 59.5 | 56.8 | 54.4 | 52.1 | 50.0 | 48.1 | 46.3 | 44.6 | 43.1 | 41.7 |
| 14 | | | | | 96.4 | 90.0 | 84.4 | 79.5 | 75.0 | 71.1 | 67.5 | 64.4 | 61.4 | 58.7 | 56.25 | 54.0 | 51.9 | 50.0 | 48.2 | 46.6 | 45.0 |
| 15 | | | | | | 96.7 | 90.6 | 85.4 | 80.6 | 76.4 | 72.5 | 69.1 | 66.0 | 63.1 | 60.4 | 58.0 | 55.8 | 53.7 | 51.8 | 50.0 | 48.3 |
| 16 | | | | | | | 96.9 | 91.2 | 86.1 | 81.6 | 77.5 | 73.8 | 70.5 | 67.4 | 64.6 | 62.0 | 59.6 | 57.4 | 55.4 | 53.5 | 51.7 |
| 17 | | | | | | | | 97.1 | 91.7 | 86.9 | 82.5 | 78.6 | 75.0 | 71.8 | 68.75 | 66.0 | 63.5 | 61.1 | 58.9 | 56.9 | 55.0 |
| 18 | | | | | | | | | 97.2 | 92.2 | 87.5 | 83.4 | 79.6 | 76.1 | 72.9 | 70.0 | 67.3 | 64.8 | 62.5 | 60.4 | 58.3 |
| 19 | | | | | | | | | | 97.4 | 92.5 | 88.1 | 84.1 | 80.5 | 77.1 | 74.0 | 71.2 | 68.5 | 66.1 | 63.8 | 61.7 |
| 20 | | | | | | | | | | | 97.5 | 93.0 | 88.6 | 84.8 | 81.25 | 78.0 | 75.0 | 72.2 | 69.6 | 67.3 | 65.0 |
| 21 | | | | | | | | | | | | 97.7 | 93.2 | 89.2 | 85.4 | 82.0 | 78.8 | 75.9 | 73.2 | 70.7 | 68.3 |
| 22 | | | | | | | | | | | | | 97.7 | 93.5 | 89.6 | 86.0 | 82.7 | 79.6 | 76.8 | 74.2 | 71.7 |
| 23 | | | | | | | | | | | | | | 97.9 | 93.75 | 90.0 | 86.5 | 83.3 | 80.4 | 77.6 | 75.0 |
| 24 | | | | | | | | | | | | | | | 97.9 | 94.0 | 90.4 | 87.0 | 83.9 | 81.1 | 78.3 |
| 25 | | | | | | | | | | | | | | | | 98.0 | 94.2 | 90.7 | 87.5 | 84.5 | 81.7 |
| 26 | | | | | | | | | | | | | | | | | 98.1 | 94.4 | 91.1 | 88.0 | 85.0 |
| 27 | | | | | | | | | | | | | | | | | | 98.1 | 94.6 | 91.4 | 88.3 |
| 28 | | | | | | | | | | | | | | | | | | | 98.2 | 94.9 | 91.7 |
| 29 | | | | | | | | | | | | | | | | | | | | 98.3 | 95.0 |
| 30 | | | | | | | | | | | | | | | | | | | | | 98.3 |

*Ob. No. = Observation Number.*





# Nylon speeds box assembly

**Use of 141 blocks of nylon, each of which holds 80 needles, is said to increase speed of assembly, reduce labor, lower weight and thus reduce machine power requirements in the manufacture of corrugated boxes. The machine is an Automatic Partition Assembler, produced by Huntingdon Industries, Inc. Du Pont's Zytel nylon resin is used to firmly grip the steel needles, which in turn grasp and hold partition pieces in various positions of manufacture.**

**Assembly racks are fed by two hopper-like tables. One table feeds partition pieces in one direction, while cross-pieces are driven home by a second table. After assembly is complete, the rack moves forward and drops the finished partition onto a conveyor. Modification of patterns of partitions is accomplished electronically from prototypes.**

**Material selection** *for high speed aircraft structural parts such as those used in this North American fighter is a complicated problem.*

*So far, only precipitation hardening stainless steels and titanium alloys can meet the severe conditions of supersonic flight. Comparison of strength-weight characteristics indicates their relative suitability for such applications.*

# Stainless vs Titanium
## for High Speed Aircraft

**by R. G. Sloan,** *Manager, Development Engineering Dept., Armco Steel Corp.*

■ Since structural metals lose strength at temperatures of 300 to 800F, the range generally experienced by the skin of airplanes flying at supersonic speeds, materials selection becomes a complicated problem. Only a few materials can qualify to meet the service requirements.

The sheet materials receiving major consideration for such structural purposes are titanium alloys and precipitation hardening stainless steels. Other sheet metals which could be given reasonable consideration for high speed aircraft structures include low alloy steels, standard stainless steels and super alloys. The limitations of these metals are given in the accompanying box.

The strongest titanium alloys now produced in flat rolled form are C-110-M and 6Al-4V. Of the precipitation hardening stainless steels, 17-7PH is receiving major consideration for high speed aircraft parts using flat rolled material. Comparisons of the properties of these materials can indicate their relative suitability for service in such applications. Most of the comparisons must be made between C-110-M and 17-7PH since only data on short-time tensile and yield strengths are available for the 6Al-4V titanium alloy.

In comparing materials, data should be reduced as nearly as possible to an equitable basis. Therefore, minimum strength values should be used wherever possible rather than so-called typical values that are difficult to use in design. Determination of minimum room temperature tensile values is usual, but it would be impossible to accomplish all the testing necessary to arrive at minimum values for all measures of strength at all temperatures. It is generally desirable to proportion short-time elevated temperature data by the ratio of minimum room temperature values to actual room temperature values for the heat being tested. This has been done in preparing the accompanying charts on short-time tensile, tensile yield, compressive yield, bearing yield and ultimate shear strength, and also on tensile and compressive moduli. However, this method has not been applied to long time properties such as stress to rupture, creep, and total deformation under load. Strength-weight ratios eliminate the density variable. Densities (lb per cu in.) used in preparing charts are tabulated below:

| | |
|---|---|
| **17-7 PH stainless steel** | **0.276** |
| **C-110-M titanium alloy** | **0.171** |
| **Commercial titanium (annealed)** | **0.163** |
| **6Al-4V titanium alloy** | **0.160** |
| **7075-T6 aluminum alloy** | **0.101** |
| **2024-TS6 aluminum alloy** | **0.100** |

# How 17-7PH Stainless and Titanium Alloys Compare:

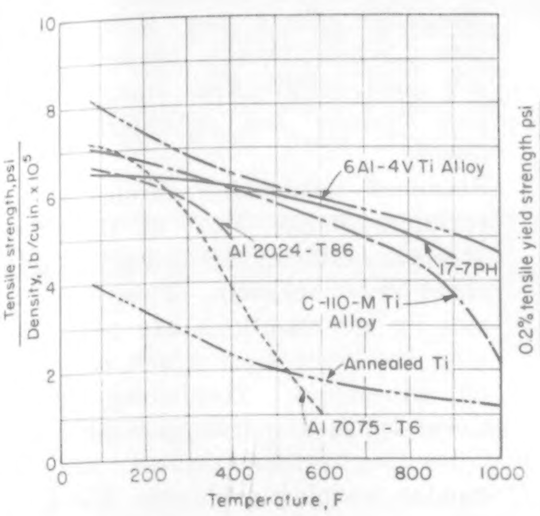



*Fig 1 Ratio of short time tensile strength to density.*

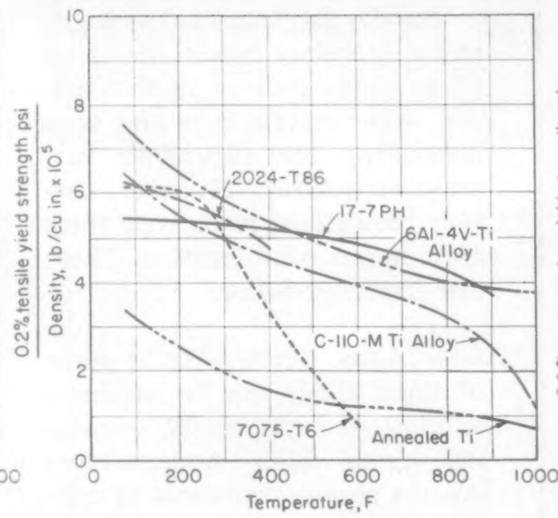



*Fig 2 Ratio of short time 0.2% tensile yield strength to density.*

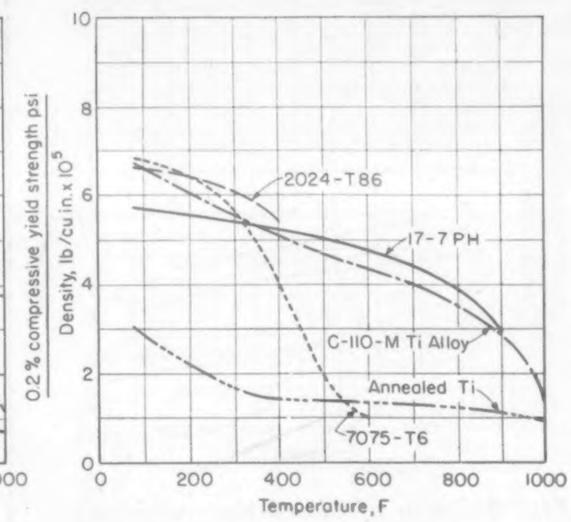



*Fig 3 Ratio of short time compressive yield strength to density.*

## 1. Short-time tension and compression

These properties are of primary importance in materials selection through the design temperature range. It has been estimated that ultimate tensile strength is a basic design criterion for 20 to 40% of an airframe structure, depending on the particular airplane. Comparisons of short-time ultimate tensile strength are given in Fig 1. The 6Al-4V titanium alloy and 17-7 PH are essentially comparable between 400 and 800 or 900F. Titanium alloy C-110-M offers somewhat lower values over 400 or 500F.

When ultimate tensile strength is used as the criterion, many engineers assume that tensile yield strength is no less than two thirds of the ultimate tensile strength. In this case permanent deformation of the components is avoided if the maximum allowable stress is determined by a safety factor of more than 1.5 on the ultimate strength. Sometimes safety factors based on yield strength are used instead. In short-time tensile yield strength 17-7 PH and 6Al-4V titanium alloy are again outstanding according to Fig 2, but their positions are reversed in the 500 to 800 F range. The values for C-110-M are somewhat lower above 300F.

Compressive yield strength for sheet materials is difficult to measure, particularly at elevated temperatures, and many designers assume it to be equal to tensile yield strength. In isotropic materials this is justifiable. Both 17-7 PH and C-110-M are in this category. Fig 3 indicates that the compressive yield strength of 17-7 PH, in the range 400 to 900F, is somewhat higher than this titanium alloy. Data for 6Al-4V titanium alloy are unavailable.

## 2. Short-time bearing strength

Where riveted or bolted joints are used, bearing stresses are checked to be sure this factor does not limit the design. In some cases limitation due to this factor may be necessary. The superiority of 17-7 PH in short-time bearing yield strength over 400F is shown in Fig 4.

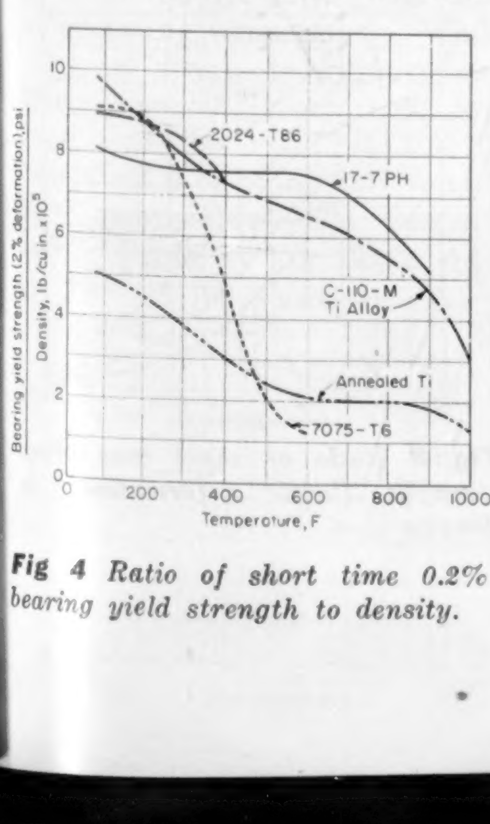
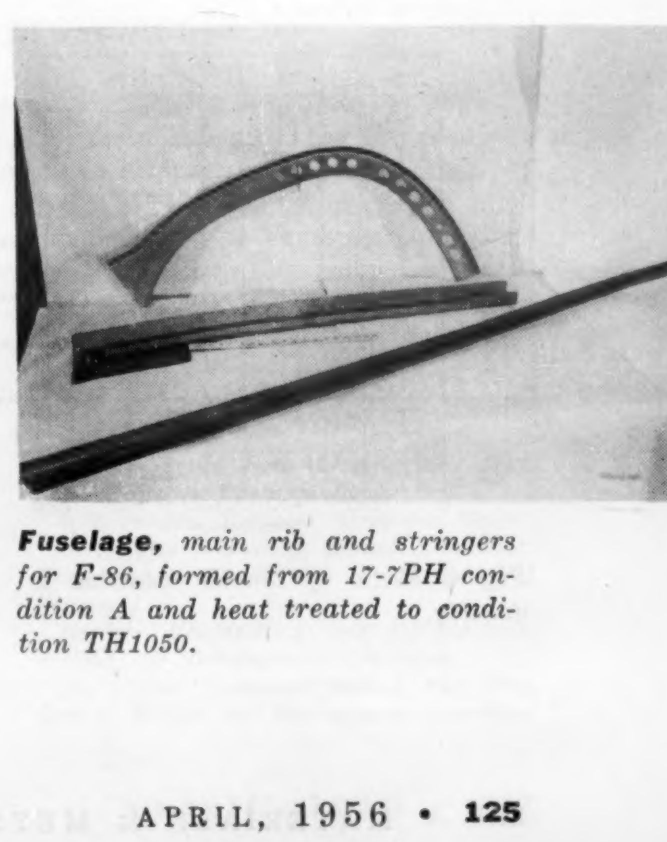



*Fig 4 Ratio of short time 0.2% bearing yield strength to density.*

In the study that developed these data it was also found that the ratio of short-time ultimate bearing strength to short-time ultimate tensile strength through the temperature range shown is the same as it is at room temperature for all these materials. Accordingly, the relationships in Fig 1 for tensile strength hold as well for ultimate bearing strength.



**Fuselage,** *main rib and stringers for F-86, formed from 17-7PH condition A and heat treated to condition TH1050.*

## 3. Shear strength

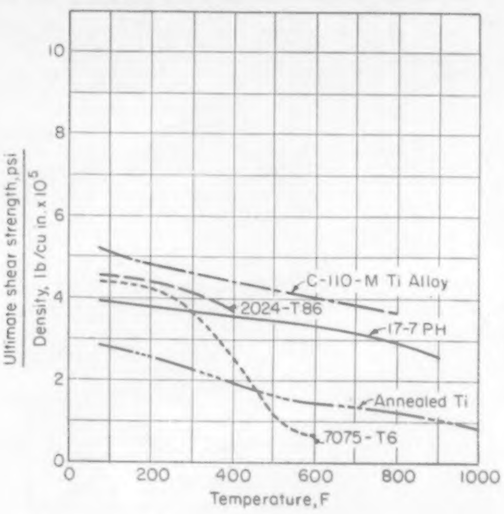



***Fig 5** Ratio of short time ultimate shear sterngth to density.*

Consideration of shear in aircraft structures usually does not limit design or affect weight as much as tensile, compressive and bending loads. Nevertheless, it is of some concern. It is apparent from Fig 5 that C-110-M has higher ultimate shear strength than 17-7 PH, although both materials exhibit useful shear values.

## 4. Tensile and compressive moduli

While not always a critical design factor, moduli of elasticity in tension and in compression are important considerations where elastic deflections may interfere with proper functioning of components. This is particularly true of flutter problems. Modulus is also important in long column design. As expected, 17-7 PH, being an alloy steel, has an advantage in modulus to weight ratio over the titanium and aluminum alloys included in this evaluation. (Fig 6 and 7)

### *Limitations of Other Materials*

Besides the precipitation hardening stainless steels and titanium alloys covered in this article, other metals have also been considered for supersonic aircraft structures. However, certain limitations have kept them from major consideration. These are discussed below.

**Low Alloy Steels**—While some of these steels can be hardened to high strength levels, quenching from high temperatures creates serious problems in control of warping or in straightening after warping has occurred. In addition, corrosion resistance is inadequate without surface protection and protective coatings cause serious problems under operating conditions.

**Standard chromium-nickel stainless steels**—Several of these alloys are used in aircraft power plants and there is some application of Types 301 and 302 in the ¼ or ½ hard tempers for critical air frame components. However, there are several limitations. Since strength is obtained by cold reduction, forming properties do not allow sufficient freedom in design. Welding affects the strength also. While tensile properties are good, longitudinal compression values are considerably lower.

**Standard hardenable chromium stainless steels**—Most of these steels are difficult to roll to plate, sheet or wide strip. Type 410 and its modifications are probably the only ones which need be considered. Hardening of these types requires quenching from high temperatures and creates warping problems. Furthermore, from the limited data available, it appears that the strength-weight ratios of Type 410 are no better than those of some of the other materials below 400 to 500F and not so good above that range.

**Super alloys**—Because of strategic alloy content and difficulty in rolling and fabricating many of these alloys, they receive little consideration for service below 1000F.

**Aluminum alloys**—These alloys lose strength rapidly with increasing temperature and lose their weight advantage when a temperature of about 300F is reached.

## 5. Short-time creep strength

It is often necessary, particularly in missiles, to withstand unusually high loads for short periods of time. If design for such

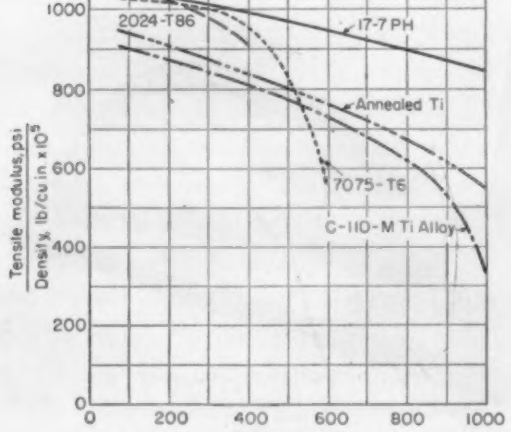



***Fig 6** Ratio of tensile modulus to density.*

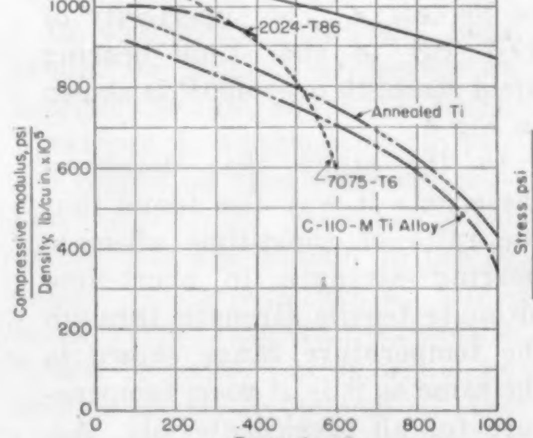



***Fig 7** Ratio of compressive modulus to density.*

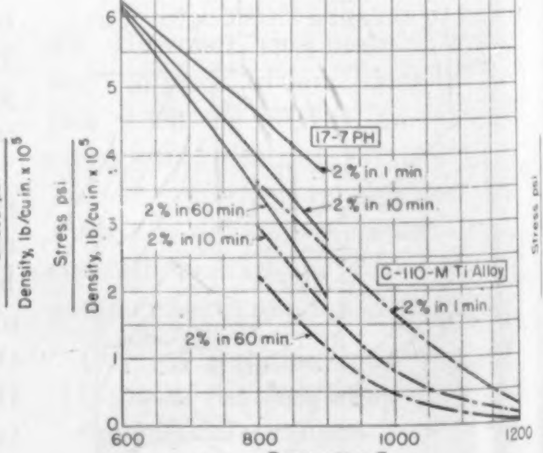



***Fig 8** Ratio of short time creep strength (0.2% deformation) to density.*

loads is based on the normally allowable stress factors, undue weight penalties can result. In such cases, a given deformation often is the limiting factor and the resultant stresses are near or beyond the 0.2% yield strength of the material, depending on time and amount of deformation permitted. One criterion for these conditions is short-time creep stress to produce 2% deformation in 1, 10 and 60 min as shown in Fig 8. Initial elastic deformation, thermal expansion and actual creep are included in the deformation measurement. Available data for materials shown overlap only in the 800 to 900F range. In this range, 17-7 PH sustains higher loads than C-110-M.

## 6. Creep stress

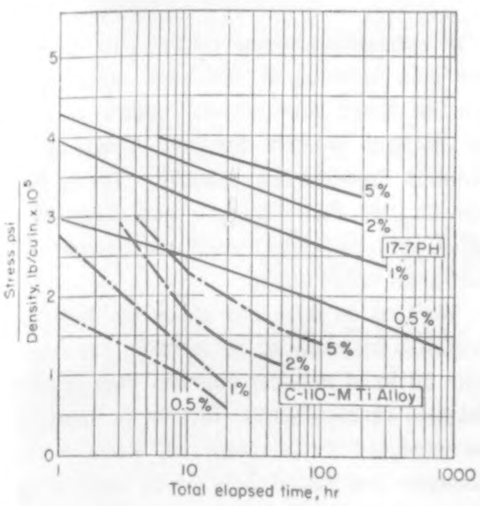



***Fig 9** Ratio of creep stress at 800 F (to produce indicated total deformation including thermal expansion) to density.*

In the design of bomber and fighter aircraft, ability to sustain loads over longer periods of time is a major consideration. One measure of this ability is creep stress, which may be shown in a number of ways.

Plotting of stress-density ratio versus time for given total deformation is often a convenient method for extended time periods. It is apparent from Fig 9 that the margin of superiority of 17-7 PH

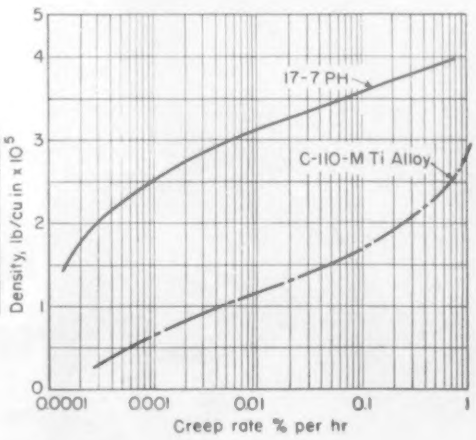



***Fig 10** Ratio of creep stress at 800 F to density.*

in resistance to creep increases markedly as time increases beyond one hour. For example, at 800F a stress-density level of 180,000 causes 0.5% total deformation in one hour with C-110-M, but requires 210 hrs with 17-7 PH.

Another useful criterion is creep rate per hour. This type of graph is based on second stage creep. Initial elastic deformation, thermal expansion and first stage creep are not included, and data must not be extended beyond the transition point where third stage creep (higher and unpredictable

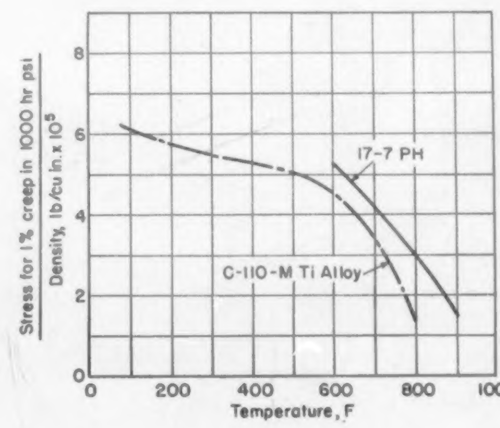



***Fig 11** Ratio of creep stress for 1% creep in 1000 hr to density.*

rates) starts. For a nominal creep rate of .001% per hr at 800F, 17-7 PH will stand about four times as much stress as C-110-M on a stress/density basis (Fig 10).

A third method often used is a graph showing stress to produce a specified amount of creep in a given time plotted versus temperature. This is useful where it is desirable to examine limiting creep factors over a temperature range. A criterion often quoted, 1% creep in 1000 hr, has been used in preparing Fig 11.

## 7. Stress to rupture

Another measure of load-sustaining-ability is stress required to cause rupture in a given time at operating temperature. While data on stress to rupture are fairly common, comparable test conditions for 17-7 PH and C-110-M could be found only for the 800F temperature. The comparison is shown in Fig 12.

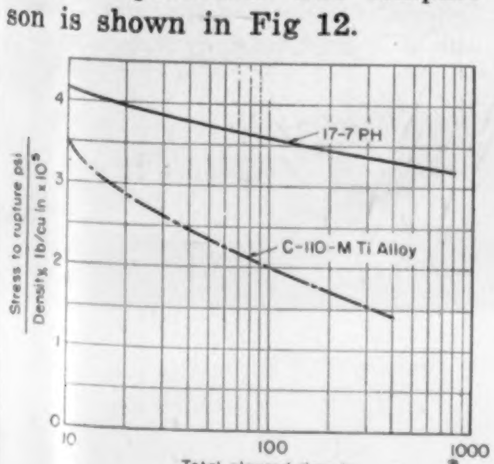



***Fig 12** Ratio of stress to rupture at 800 F to density.*

### *Future Improvements*

**Research on the precipitation hardening grades continues to show promise although developments cannot be discussed until they are ready for commercial production. Modifications in composition and heat treatment of 17-7 PH, on the way, will provide substantial improvement in properties at room and elevated temperatures. For example, a heat treatment has been developed that will result in 10 to 15% improvement in room temperature properties. The innovations will be announced when commercial feasibility has been demonstrated.**

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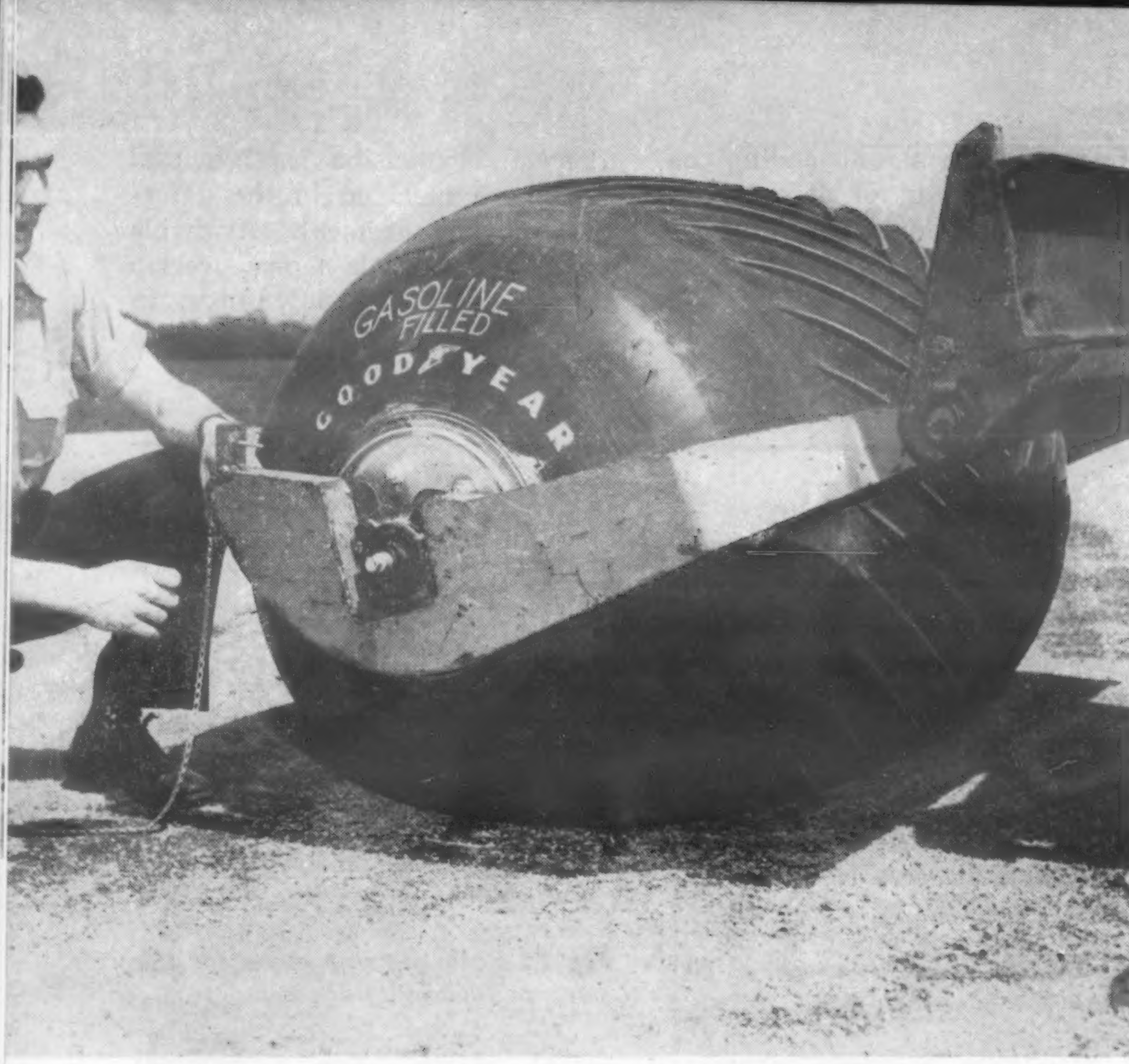
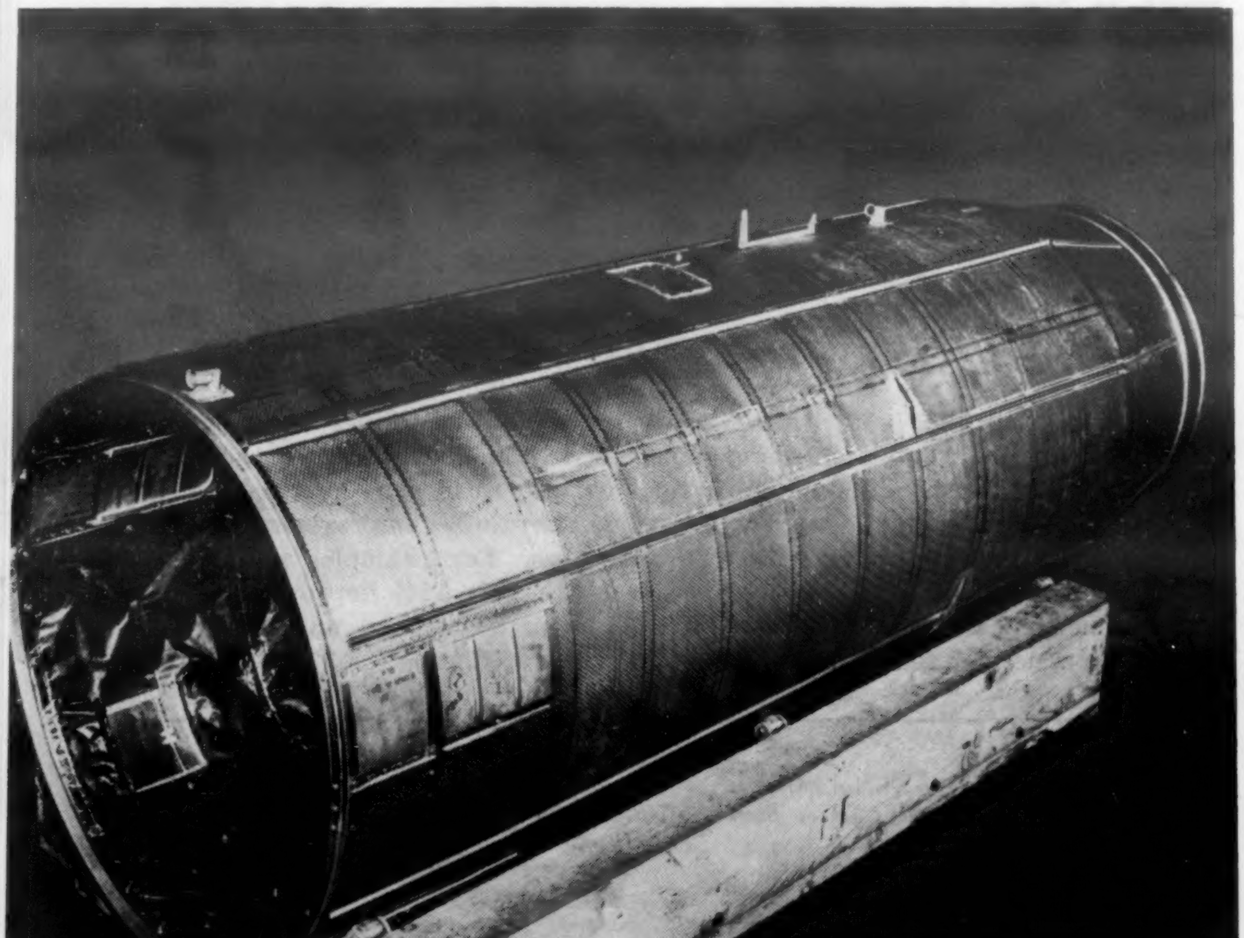



# Rubber "watermelon" totes liquids

A watermelon-shaped rubber tank designed for bulk handling of fuels and other liquids can be rolled over ground, floated in water or dropped without bursting. Developed by Aviation Products Div., Goodyear Tire & Rubber Co., the Rolli-Tanker is actually a tire of nylon cord and tread-stock construction with fuel-proof inner lining.

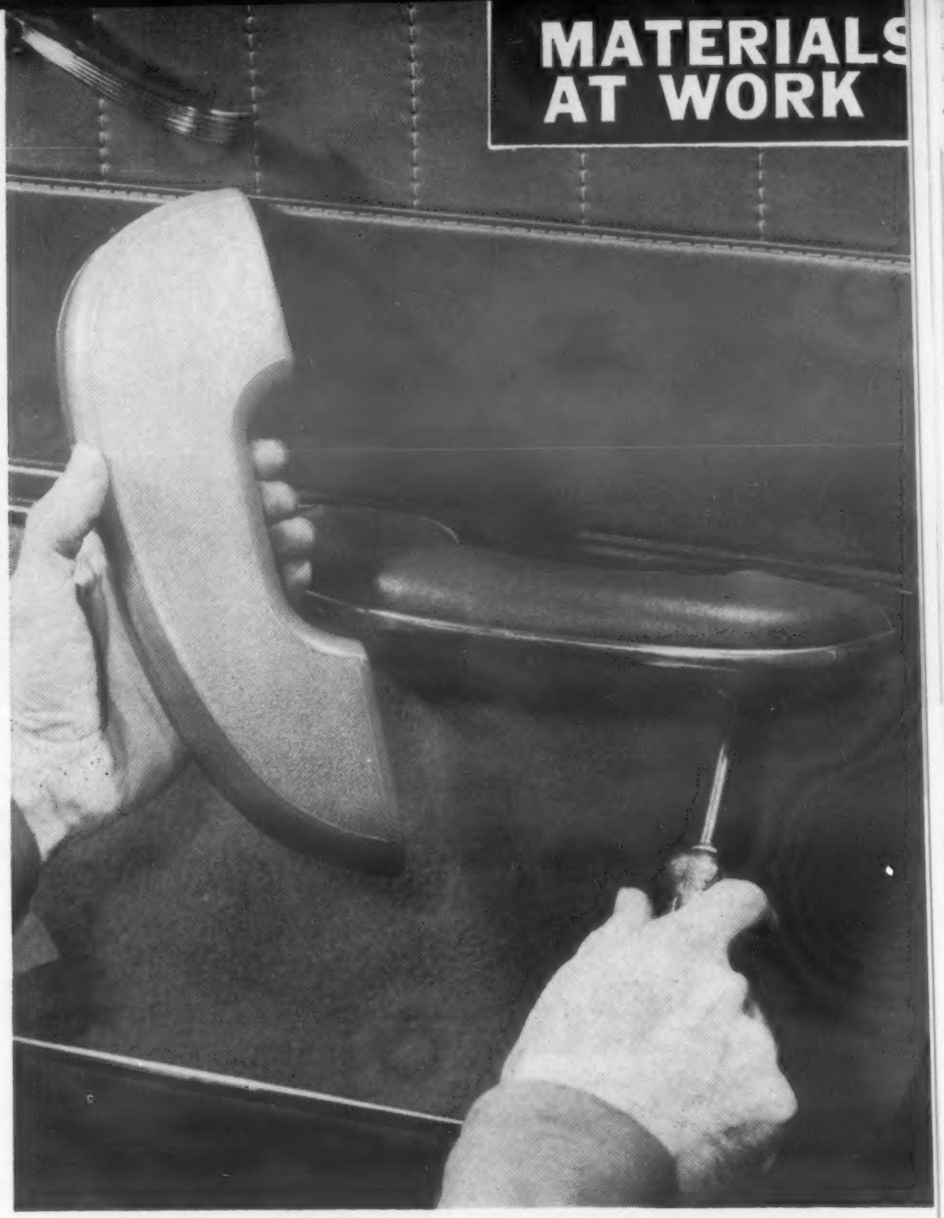
Mounted on hubs and axles, the tanks can be towed manually or by vehicle. They require only 30 lb of drawbar pull and have excellent flotation characteristics. Though the tanks can be produced in a range of sizes, to-date Goodyear has tested 3-1/2x5-ft tanks weighing 40 lb deflated and having a 250 gal capacity.



# Embossing strengthens titanium

Embossed or "rigidized" titanium is now being used in the shroud for the J-57 jet engine. The shroud is used to insulate the engine from surrounding fuselage. The embossing operation is said to increase stiffness of the material by about 155%, which permits reduction in sheet thickness, and a subsequent 25% reduction in weight of material. Called Rigid-tex titanium, the sheet is produced by Rigidized Metals Corp.

Previously-used flat sheet titanium had to be riveted, and would wrinkle to some degree. Embossed titanium is seam and spot welded with no resulting wrinkling or buckling.

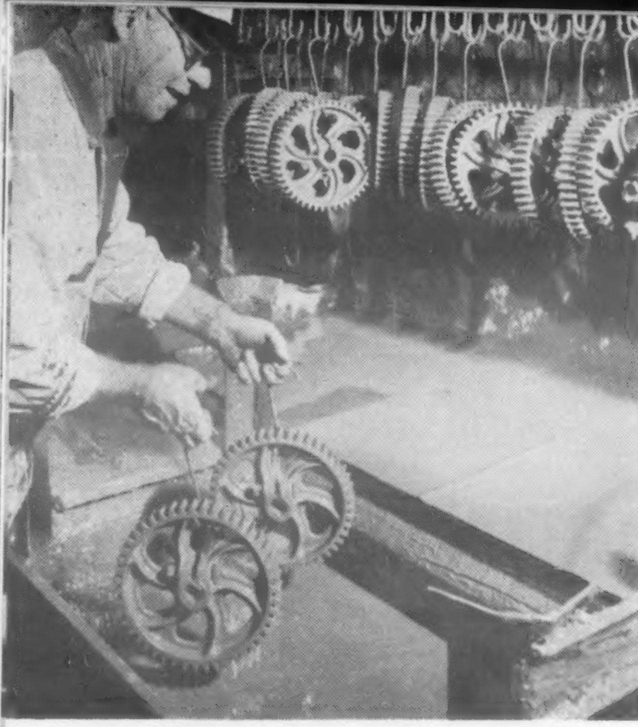


## Polyethylene guards arm rest

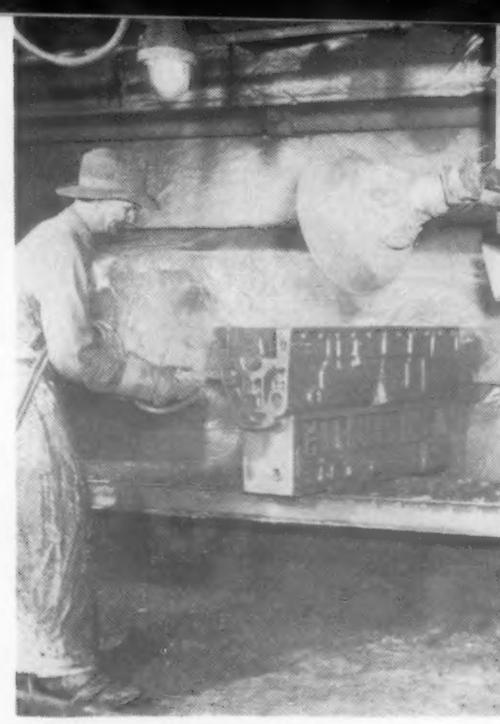
Molded polyethylene arm rests, in a variety of colors, are being used to protect new upholstery and conceal worn upholstery on automotive arm rests. Molded by Easy-Fit Corp. of Eastman Chemical Product's Tenite polyethylene, the covers are semi-flexible and have a soft resilient surface, retaining the padded effect of the upholstery.

## Accurate complex zinc die castings

Parts shown are indicative of the extreme complexity possible with zinc die castings. All the parts are components of an awning window manufactured by Denison Corp. At upper left is the drive gear assembly and housing; upper right, jamb assembly and housing; lower center, hinge bracket, mounting bracket and hand crank.



**Gear blanks** *are dip-coated for protection during storage. Later they are machined to size, the coating preventing penetration of lubricants.*



**Engine block,** *sprayed in a 45-sec cycle, is then conveyed to outdoor storage areas where coating protects metal against weather.*

**Axle housings,** *dipped in a 20-sec cycle, pass under lamps and are dry enough after 6 min to permit stacking as shown here.*

# Rubber-Modified Alkyd Sealers

*Compared to conventional lacquer sealers, these relatively new finishes . . .*

- *Have better weather resistance*
- *Cost less per mil*
- *Dry almost as fast*

■ At one time sealers for castings were made chiefly from reject batches of lacquer mixed with enough pigment to provide a uniform color. The quality, viscosity and solids content of these scrap-based sealers—and consequently the protection afforded by them—naturally varied widely from batch to batch.

In recent years a number of new sealers have been developed to meet the long-felt need for a uniform and effective, yet economical, finish. Lacquers used as sealers have been improved. Air-drying alkyd sealers are now under commercial development. But one new type, the chlorinated rubber-modified alkyd or "Parlon" sealer, not only seems to offer significant advantages over conventional lacquer sealers but also has a three year record of successful commercial use. This article is believed to be the first published on these new finishes.

### Requirements and functions

Sealers have been used on castings for four reasons: 1) to seal in excess foundry sand, preventing damage to gears and other moving parts; 2) to resist penetration of hot oil into the casting, with resulting enlargement of any minor flaws in the metal; 3) to protect parts from weather corrosion during transit or temporary yard storage; and 4) to act as prime coat in subsequent finishing.

Requirements for casting sealers are well established. They must dry fast. Within 24 hr the coating must be capable of being machined without chipping or flaking, and it must withstand washing in boiling trisodium phosphate and caustic soda without film breakdown. In the field it must withstand immersion in water, in 275F transmission oil, in anti-freeze solutions and in detergent motor flush solutions.

As the accompanying table indicates, drying time of the rubber-modified alkyd sealer is longer than that of the conventional lacquer sealer. In all other respects, however, the new sealers appear to be superior to the old.

### Properties

Particularly important is their outstanding resistance to weathering. For some castings, such as automotive engine blocks and transmission parts, a sealer may be the only protective coating applied during the life of the parts. Heavy castings such as engine blocks may also be stored outside for a considerable length of time. Parts sealed with the rubber-modified alkyds have been exposed outdoors for more than six months without showing any evidence of corrosion or film breakdown, even in environments characterized by broad temperature changes, high humidity and other adverse conditions.

The new sealers have other de-

***Tractor parts,*** *sprayed in a 66-sec cycle, reach unloading station 8 min after painting. Parts shown are axle carrier and front bolster.*

***Main frame*** *of crawler-type tractor.* *(All photos courtesy Hercules Powder Co.)*

# for Castings

**by O. L. Campbell,** *Tousey Varnish Co.*

sirable characteristics, both as interim finishes and as primers. They provide a tough, durable adherent film which machines cleanly, yet keeps machining lubricants from penetrating the casting. Because of their excellent adhesion and their resistance to attack by high-detergency oils, they are used on transmission housings to seal in residual grit picked up in the casting operation, thereby keeping it out of the gear train. Conventional sealers were tried but broke down completely in contact with the lubricating oils. The adhesion and the chemical resistance of these sealers makes them a good base for an enamel top coat.

Another advantage of the rubber-modified alkyd sealers is their higher flash point—30 deg higher than that of conventional lacquer types—which provides a greatly increased safety factor in plant operation.

Despite a higher original cost per gallon, the new sealers actually cost less to use than the lacquer types. Ability to use higher solids content and less expensive reducer makes it possible to get substantially greater coverage with the new sealers, as indicated in the table. In addition, film thickness is greater—markedly so when the dipping process is used. The thicker film further increases the protective value of the rubber modified alkyd sealers.

Although the dry-to-handle time for the new sealers is longer than for the lacquer types, it is still within the range needed for a fast, uninterrupted production cycle. In 12 min or less, depending on whether they are air dried or baked under lamps, sprayed or dipped parts are tack-free and can be stacked or packaged as required. Standard spray booth or dip tank equipment can be used. So far, no application has been found where the increase in drying time of a rubber-modified alkyd sealer compared to a lacquer type was sufficient to prevent the prompt movement of painted parts to the next stage of production.

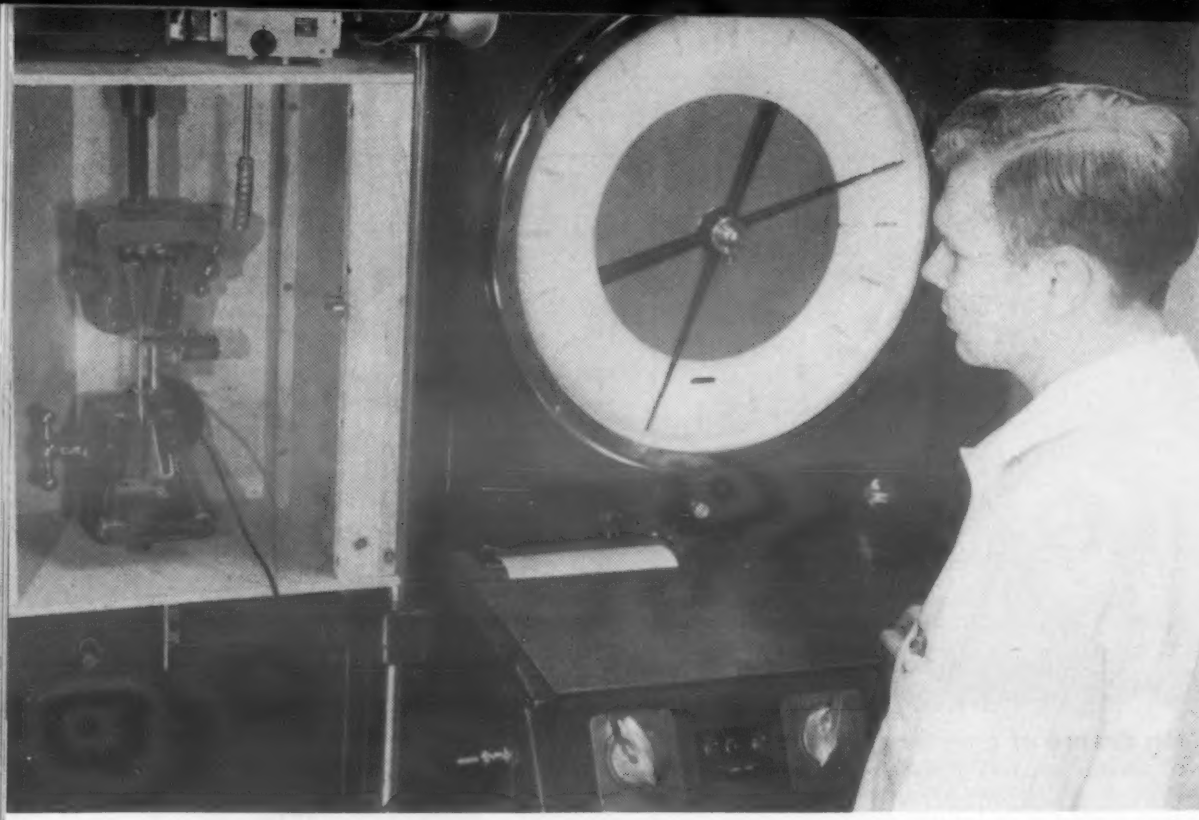
## *Chlorinated Rubber*

Chlorinated rubber is made by Hercules Powder Co. under the tradename "Parlon". It consists essentially of natural rubber reacted with chlorine to yield a hydrocarbon polymer containing about 67% chlorine. The high chlorine content makes this material nonflammable and highly resistant to both weak and strong acids and alkalies.

As a modifier for medium to long oil alkyd enamels, chlorinated rubber provides: reduced drying time and dust pickup; increased hardness, mar resistance, humidity resistance, salt spray resistance and abrasion resistance; and easier cleaning. Rubber-modified enamels are being used not only as sealers but also to some extent as product finishes, particularly for parts of trucks, buses, farm machinery and similar products where a hard, glossy finish is desired, where corrosion resistance is important, and where baking is not always feasible because of the size of the part.

**COMPARISON OF LACQUER AND RUBBER-MODIFIED ALKYD SEALERS**

| | Parlon Sealer | | Conventional Sealer | |
|---|---|---|---|---|
| Dry-to-handle Time | 12 min | | 5 min | |
| Flash Point | 65 F | | 30 F | |
| | Dip | Spray | Dip | Spray |
| Coverage: | | | | |
| Square feet per reduced gallon | 450 | 171 | 254 | 101 |
| Dry film thickness, mils | 0.60 | 0.52 | 0.33 | 0.4 |



***Effects of temperature** on tensile properties can be determined by using an environmental chamber in the tensile test set-up.*

# Developing Design Data for Plastics

*More complete data than are usually available on plastics are necessary to permit designers and engineers to adequately design plastics structural products. To illustrate this point, the authors present the latest engineering data on a new high impact thermoplastic resin.*

**by R. K. Multer,** *Marbon Chemical Div.,* **and R. H. Rayfield,** *Central Research Lab., Borg-Warner Corp.*

■ The conventional listing of mechanical and physical properties of plastics is often inadequate for optimum engineering and design of plastics products. The data do not usually take into account effects of time, environment and method of fabrication, and can therefore be misleading. The purpose of this article is to show how conventional data can be extended to give more complete and realistic design information. In so doing, the article presents the latest and most complete engineering information on a relatively new thermoplastic material, called Cycolac.

Conventional strength properties usually used to describe plastics are shown in Table 1. Tests to obtain these values all measure the same few fundamental properties, under different arbitrarily established conditions of temperature and loading rate.

To supplement these arbitrary, comparative values, it was felt that to fairly well characterize the short-term strength of a plastics, tensile properties of the material should be determined over a wide range of temperatures and loading rates.

### Effects of temperature

Stress-strain curves at temperatures spanning the useful range of Cycolac are shown in Fig 1. Their general shape is similar to those of metals, i.e., at light loads stress is proportional to strain, up to a maximum tensile stress, after which strain increases rapidly at a slightly reduced load. At 74 F the proportional limit, that point on the stress-strain curve after which stress is no longer proportional to strain, is about 2500 psi at 1% strain. The yield point or tensile strength is about 4700 psi at 3% strain. Elastic limit was found to be about 4000 psi at

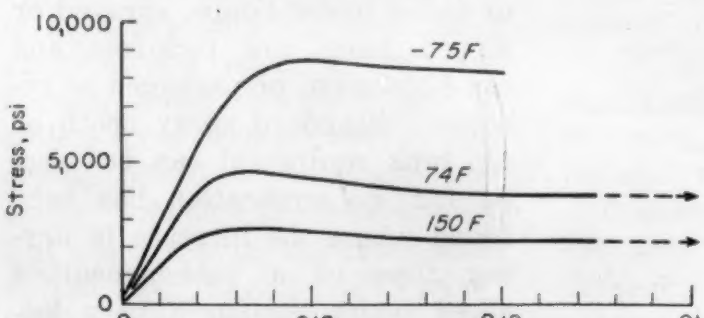



***Fig 1** Effect of temperature on tensile stress-strain curves for Cycolac. Crosshead speed was 0.07 in. per min.*

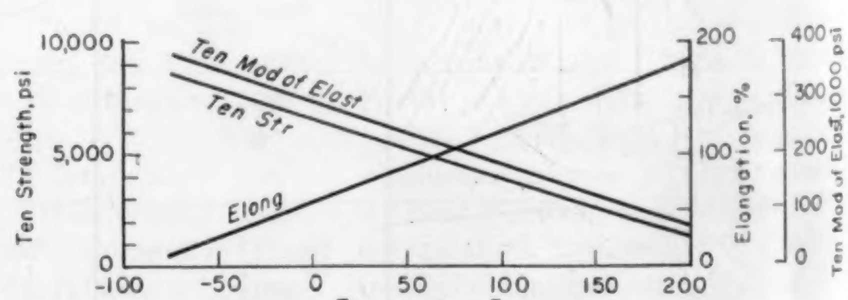



***Fig 2** Effect of temperature on tensile strength, modulus and elongation. Crosshead speed in all cases was 0.07 in. per min.*

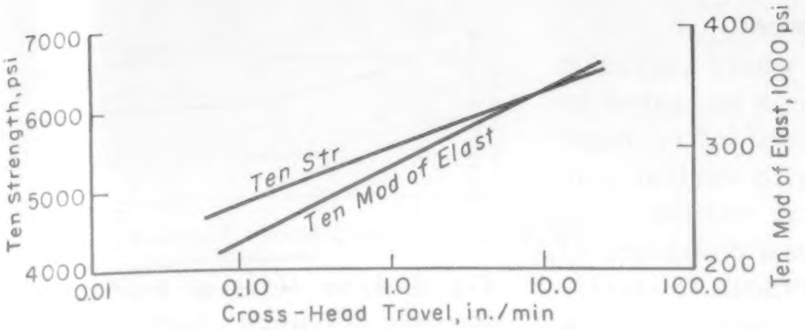



*Fig 3 Effect of strain rate on tensile strength and modulus at 74 F.*

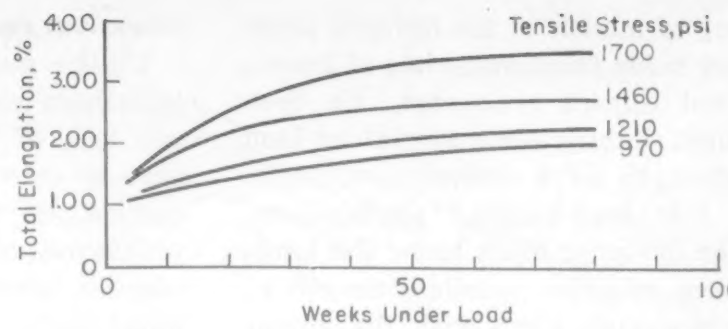



*Fig 4 Creep of Cycolac at 74 F at various stresses.*

2% elongation. As should be expected with this type of plastics, strength and modulus are higher at low temperatures and elongation is lower. See Fig 2.

**Effects of loading rates**

There is no such thing as a static tensile test on plastics. The shape of the stress-strain curve is dependent on the rate of loading. Fig 3 shows effects of varying the strain rate over as wide a range as was possible with the conventional testing machine available. Both tensile strength and tensile modulus increase as the strain rate is raised. Elongation (not shown because of difficulty in measuring it at high rates) diminishes considerably with increases in strain rate. Properties vary measurably even between the two strain rates specified by ASTM for modulus and strength measurements, i.e., 0.05 and 0.25 in. per min.

Testing machines currently being developed may soon permit ready measurement of stress-strain effects at impact loading rates, and permit calculation of rupture energy in terms of ft-lb per sq in. for a given thickness. Until that time the designer concerned with shock stresses must be content with destructive test-

**TABLE 1—**
**TYPICAL MECHANICAL PROPERTIES OF CYCOLAC**

(Injection molded specimens)

| Property | ASTM | Value |
|---|---|---|
| Ten Str, psi | D638-52T | 4500 |
| Elong, % | D638-52T | 100 |
| Ten Mod of Elast, psi | D638-52T | 200,000 |
| Izod Impact, ⅛ in. ft-lb/in. notch | D256-47T | 5.0 |
| Hardness, Rockwell | D785-51 | R90 |
| Heat Dist, F | D648-45T | 200 |
| Brittle Point, F | D746-44T | Below—45 |

## The Material

The data presented in this article pertain to Cycolac, a high-impact thermoplastic polymer containing acrylonitrile, butadiene and styrene. It has been commercially available since 1953. It can be formed by injection molding, extrusion, or post-forming of heated sheet. It can also be shaped and assembled by conventional metal and woodworking techniques, such as sawing, punching, heat-sealing, adhesive or solvent bonding and riveting.

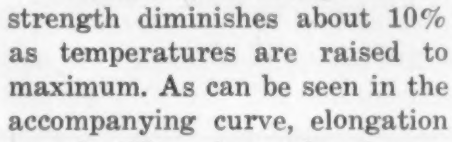
Since the material is most commonly formed by injection molding, test specimens for gathering all data were injection molded. Molding cycles were selected to provide material with maximum strength.

**Effect of molding variables**

Temperatures, pressures, cycle times, reground content, etc., all affect the properties of molded parts. With most thermoplastics there is a workable range between minimum processing temperature and the decomposition temperature. However, it is often economically impractical to process under conditions giving maximum physical strength. Thus it is desirable to know how much strength will be sacrificed when temperatures are raised to shorten the molding cycle.

Tensile bars of Cycolac were injection molded at cylinder temperatures ranging from 460 F (minimum temperature permitting filling of mold cavity at maximum pressures) to 600 F. Within this 140 F range tensile strength diminishes about 10% as temperatures are raised to maximum. As can be seen in the accompanying curve, elongation or ductility is reduced appreciably as the temperature is raised. Elongation is also affected by injection pressures, the highest pressures producing the most ductility.

Strength of the finished product can also be influenced by orientation or grain effects, and by trapped stresses created by cold deformation and thermal shrinkage. Cycolac appears to be relatively free of orientation phenomena, and its high ductility minimizes seriousness of trapped stresses.




*Ductility of Cycolac vs molding temperature.*

ing of models of the finished product made from materials of known Izod impact resistance. He then must specify his material by Izod strength on a comparative basis.

For load-bearing applications, the designer must know the long-term effective tensile strength of a material. Even with the lowest strain rate studied with conventional tensile testers, fracture generally occurs in under two hours. With most thermoplastics, failure will occur within a few days at stresses not far below the tensile strength as determined by ASTM test procedures. In creep testing, the stress is a small percentage of the short-time strength, and time to fracture is on the order of weeks or years. The designer's problem is to keep stresses down to a point where total deformation will be within practical limits during the service life of the product. Fig 4 shows creep data for several loadings at room temperature on compression molded and extruded specimens. Data are averaged since no significant differences were found.

**Chemical resistance**

Unlike metals where corrosion resistance usually is measured by the loss of material after exposure to chemicals in various concentrations and at various temperatures, corrosion resistance of plastics is more difficult to specify numerically. The chemical attack is most often internal, involving softening, swelling and loss of strength. Test methods are not available for quantitatively measuring service strength of plastics under chemical attack. In measuring chemical resistance, plastics must be stressed during immersion since stress-corrosion effects are so prevalent. Data based on tests run after cleaning and conditioning plastics specimens are, for the most part, unreliable.

Table 2 lists some chemicals which do not appreciably affect Cycolac, even under stress. Cycolac is dissolved or softened by strong organic solvents and is degraded by concentrated nitric and sulfuric acids. For other chemicals, serviceability depends on specific conditions of use, such as shape of product, method of fabrication, magnitude of stress, duration of stress, desired service life of product, temperature, concentration of chemicals, and what kind of change is designated as failure.

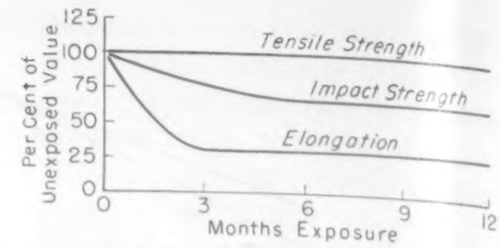



***Fig 5*** *After three or four months exposure to sunlight, tensile strength remains unaffected while impact strength and elongation are substantially reduced.*

**Aging and environment**

Since plastics are frequently used unpainted, the effect of aging and environmental conditions on their properties must be established. Age alone does not affect Cycolac, since it contains no volatile or liquid ingredients to evaporate or migrate. Humidity and moisture likewise appear to have no effect on strength.

Fig 5 shows the effect of sunlight on tensile strength, elongation and impact strength of Cycolac. Reduction in elongation and impact are due to formation of a hard, non-ductile layer on the surface. After this skin has formed, there is little further loss in properties. Burial in soils, and immersion in sea water do not affect tensile properties. After a year's burial in various types of soils and immersion in sea water, tensile strength and elongation were unaffected.

Accelerated aging by oxygen bomb at 158 F and 300 psi does not lower tensile strength, though elongation falls off after about 50 hr.

**Application of data to design**

Usefulness of tensile data at the design level can be checked by comparing it with results of destructive tests on commercial

**TABLE 2—CHEMICALS RESISTED BY CYCOLAC UNDER STRESS AT 70 F**

**Surface-active Agents in Water**
- Armeen 18 D, 1%
- Calgon, 1%
- Duponol C, 1%
- Emulfor EL-719, 1%
- Ethomeen C/20, 1%
- Santomerse No. 3, 1%
- Soap, bar, 10%
- Soap, Rubber Reserve, ½%
- Soilax, 1%
- Span 40, 1%
- Tergitol, NPX, 1%
- Tween 40, 1%
- Vel, 1%

**Inorganic Salts in Water**
- Calcium chloride, 10%
- Calcium hypochlorite, 10%
- Calcium sulfate, saturated
- Copper acetate, 10%
- Copper chloride, 10%
- Ferrous sulfate, saturated
- Potassium dichromate, saturated
- Sodium acetate, 10%
- Sodium bicarbonate, saturated
- Sodium bisulfate, 10%
- Sodium bisulfite, 10%
- Sodium carbonate, 10%
- Sodium cyanide, 10%
- Sodium chloride, 10%
- Sodium pyrophosphate, saturated
- Sodium tetroaborate (borax) saturated

Alkalies in Water
- Ammonium hydroxide, 15%
- Sodium hydroxide, 10%, 50%

**Acids in Water**
- Citric, 10%
- Hydrochloric, 30% (discolors)
- Lactic, 10%
- Nitric, 2%
- Oxalic, 10%
- Phosphoric, 50%
- Sulfuric, 50%

**Organic compounds and miscellaneous**
- Coca Cola
- Glycerine
- Hydrogen peroxide, 30%
- Lubricating oil
- Mercaptans, (C-12 to C-14)
- Sour Crude Oil

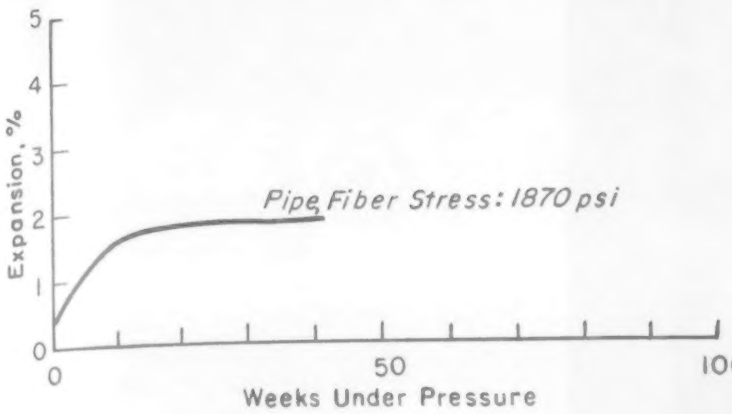



**Fig 6** *Creep in pipe held under safe long-term stress as determined by burst tests.*

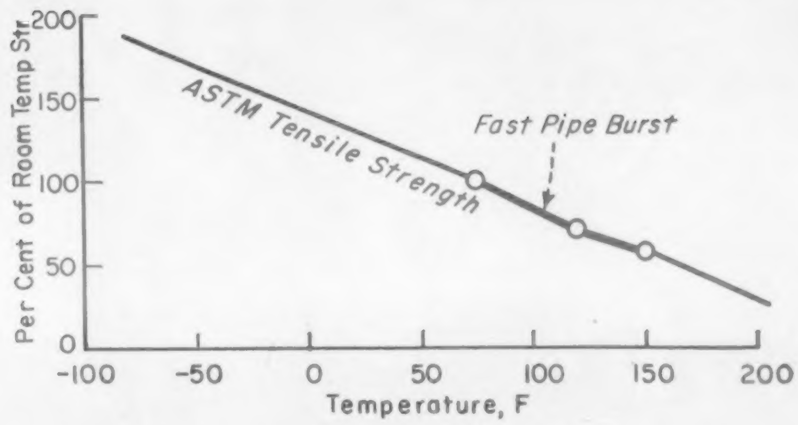



**Fig 7** ***Effect of temperature on short-term pipe burst strength is compared with strength-temperature relation taken from Fig 2.***

structural applications such as extruded pipe. After destructively testing pipe by running short and long-term burst tests, as well as burst tests at high temperatures, results were substituted in an equation for burst strength and values for short-term and long-term tensile strength obtained. The degree of correlation between these values and tensile values previously obtained would be a measure of the effectiveness of the latter values for purposes of design.

The equation used for burst strength was:

$$P = \frac{2ST}{D}$$

**where P = internal burst pressure, psi**
**S = effective tensile strength, psi**
**T = wall thickness, in.**
**D = outside diameter, in.**

Substituting results of burst tests in this equation, effective short-term tensile strength was found to be 4730 psi, effective long-term strength 1690 psi. The exact strain rate during a short-term pipe burst test is difficult to estimate; however, calculating from increased diameter of burst pipe, it was found to be on the order of 10% per min. equivalent to a tensile tester crosshead travel of about ¼ in. per min. The short-term strength value corresponds well with tensile strength values in Fig 3 for a crosshead travel of ¼ in. per min.

Effect of a long-term stress of 1870 psi is shown in Fig 6. Long-term strength of 1690 psi was arrived at by deducting 10% for variations in material as can be seen, after loading for 45 weeks, expansion of the pipe, or creep, has reduced to zero.

From the design standpoint, Fig 4 shows that if a 3% elongation is permissible during the service life of the structure, a stress of 1690 psi is a permissible load since creep will diminish to zero after reaching a 3% elongation. Of course, this value does not include a safety factor. Magnitude of safety factor depends on details of service, hazards, dimensional uniformity, reliability of installation and other engineering criteria.

Fig 7 shows effects of high temperatures on short-term burst strength, compared with a strength-temperature relation taken from Fig 2. Pending long-term, high-temperature tests, it can only be assumed that long-term strength follows this same relation to temperature.

Outdoor aging and accelerated ultra-violet exposure had no effect on burst strengths. Although there was some discoloration of gray pipe and some slight loss in surface ductility, the pipe could not be made to fail by impact, and its usefulness did not seem impaired.

## *What Conventional Tests Mean*

Tensile strength and elongation to failure are measured directly, using specimens of a standard size and shape, at 73 F, with a relatively slow testing speed of ¼ in. per min. Tensile modulus of elasticity is measured with the same specimen, under the same conditions except that the rate is reduced to 0.05 in. per min to aid correlation of stress with strain over the straight-line portion of the stress-strain curve.

Impact tests measure the amount of energy required to fracture a specimen by rapid bending of a notched bar. Though stress analysis of the standard Izod specimen is impossible due to the geometry of the specimen, test results appear to agree with the theory that what is really indicated by the impact test is the total area under the high-rate tensile stress-strain curve. Rockwell hardness is often used within a group of similar materials as an indication of tensile strength. In effect, the test indicates surface yield strength by measuring the area required to resist a fixed load, applied slowly.

The heat distortion test measures a combination of tensile properties at high temperatures. The temperature is determined at which an arbitrary, fairly high strain is reached under a fixed, low, stress applied by center-loading a beam for a fixed time. Brittleness temperature indicates how much a material must be cooled to reduce its tensile elongation to a very low value, when measured at a high strain rate.

# Hot zinc bath guards steel

Galvanizing steel water tanks by dipping in molten zinc provides a high degree of corrosion protection to otherwise vulnerable steel. This picture of the dipping operation is from a film produced by the American Zinc Institute on corrosion control.

# Powder metallurgy cuts guide wheel cost

The unusual shape of this guide wheel for an oven broiler tray makes powder metallurgy a "natural" method of fabrication. The V groove, undercut shoulders on each side and a center bearing hole would require costly machining.

By powder metallurgy techniques, the part is made in two parts, as shown. Each of the compacts is made of a different iron pewder mix, one with a positive growth factor, the other with a negative. The green compacts are fitted together and sintered. Reaction to heat produces a sintered union said to be as strong as the body of the part. After sintering, wheels are impregnated with resin and plated. They are compacted sintered and impregnated by Brockway Pressed Metals, Inc., for the Plastic Metals Div., National-U.S. Radiator Corp.

*Stainless steels have been developed for specific properties or applications. This wind tunnel utilizes precipitation hardenable stainless.*
*(U. S. Steel Corp.)*

# The New Stainless Steels

by D. B. Roach and A. M. Hall, *Battelle Memorial Institute*

*New stainless steels have been developed in recent years to alleviate the problems created by shortages of strategic raw materials or to provide special properties for particular applications. This manual discusses the properties and applications of—*

- *High Manganese Grades*
- *Extra Low Carbon Grades*
- *Wrought Precipitation-Hardenable Grades*
- *Cast Precipitation-Hardenable Grades*
- *Ferritic Stainless Steels for Elevated Temperature Service*

**MATERIALS & METHODS MANUAL No. 126**

**This is another in a series of comprehensive article on engineering materials. These sections provide the reader with useful data on characteristics and uses of materials, parts and finishes.**

APRIL 1956

# Introduction

■ During the past few years interest in stainless steels has turned sharply upward. This family of materials has found greatly increased use in the aircraft, appliance, architectural, automotive, chemical and construction fields. Not only has demand for standard tonnage items increased but in addition new applications are calling for special compositions to meet specific requirements.

This situation in itself would be enough to present a stimulating challenge to the stainless steel producer but he is faced also with a dismal raw materials picture. Because of defense requirements and unprecedented civilian demand, nickel will probably be in short supply for years. Therefore, the stainless steel industry has gone to work to develop new compositions in an effort to meet consumer demands. Several compositions are designed to alleviate the problems created in tonnage items by shortages in strategic raw materials. Others have been developed to provide special properties for particular requirements.

Such steels as the high manganese, low-nickel grades, represented by AISI 201 and 202, have been developed to circumvent the nickel shortage. The extra-low carbon types were originally designed to mitigate the effects of columbium shortages, but are finding a place of their own.

Other high manganese and ferritic compositions are designed for special applications particularly at high temperatures. In addition, several families of age-hardenable stainless steels have appeared. These steels combine high strength with stainless qualities and have a wide variety of potential uses.

To give a comprehensive discussion of all the stainless steels of recent vintage would require the preparation of a textbook and would be outside the scope of this manual. Instead, several important classes have been selected and illustrative alloys within each class are discussed.

# High-Manganese Grades

The continuing shortage of nickel has forced the steel industry to investigate low nickel austenitic stainless steels to conserve the available supply. As a result, two low nickel, high manganese compositions have been developed sufficiently to be designated as AISI standard steels. These are AISI Types 201 and 202. Two other austenitic stainless steels designated CMN and G-192 containing no nickel have been developed primarily for elevated temperature service. Compositions of the four grades are tabulated. Other nickel-free chromium-manganese-nitrogen steels are in various stages of development.

Industry plans call for warehousing Types 201 and 202 this Spring in the forms in which Types 301 and 302 are now supplied. For Type 201, sheet and strip forms will be emphasized; for Type 202, emphasis will probably be placed on rod and bar stock.

At present CMN is made principally into sheet and castings. G-192 is designed to be a wrought high temperature alloy, and much of it would be used in the form of machined forgings.

### Mechanical properties

AISI 201 is similar to Type 301 (17Cr-7Ni) in mechanical properties, response to cold working, and rate of work hardening. However, it tends to develop a somewhat higher yield strength at a given cold reduction than does the 17Cr-7Ni steel, while retaining as much ductility. AISI 202 is comparable to Type 302 (18Cr-8Ni) in mechanical properties. Like Type 302 it does not work harden as rapidly as Types 201 and 301.

Both Types 201 and 202 have excellent toughness at ambient and low temperatures, but the higher nickel grade gives somewhat higher impact values because of greater structural stability. Izod values at −298F for Type 201 are in the order of 70 ft-lb, while for Type 202 they run 90-120 ft-lb.

CMN was developed primarily for high temperature applications. In both the as-cast and wrought conditions it shows high-temperature strength equivalent or superior to the better heat resistant cast and wrought iron-nickel-chromium alloys. G-192 was also developed primarily for applications involving elevated temperatures. Available data suggest that it may have slightly less strength but more ductility than CMN.

**COMPOSITION OF NEW HIGH-MANGANESE GRADES**

| Designation | C | Mn | Cr | Ni | N |
|---|---|---|---|---|---|
| AISI[1] 201 | 0.15 max | 5.5/7.5 | 16.0/18.0 | 3.5/5.5 | 0.25 max |
| AISI[1] 202 | 0.15 max | 7.5/10.0 | 17.0/19.0 | 4.0/6.0 | 0.25 max |
| CMN[2] | 0.65 | 12 | 25 | — | 0.45 |
| G-192[3] | 0.55/0.65 | 8.0/9.0 | 21.25/22.75 | — | 0.30/0.40 |

[1] *Designation of the American Iron and Steel Institute*
[2] *Crucible Steel Company of America*
[3] *Allegheny Ludlum Steel Corporation*

### Corrosion resistance

Periodic observation of rail cars and truck trailer units constructed of Type 201 during the past five years has shown that this steel is satisfactory against atmospheric corrosion. Specimens of Type 201, exposed for various periods up to 3 yr in a number of severe industrial atmospheres, have shown no significant corrosion. Results of laboratory corrosion tests are given in a table. In addition to the corrosion rates given, specimens of Types 201 and 301 showed no intergranular attack in boiling nitric acid or acid copper sulfate solutions. These tests indicate that Type 201 compares favorably with Type 301 and Type 202 is comparable with Type 304. Specific data on CMN and G-192 were not available. However, the manufacturer reports that G-192 shows good resistance to oxidation and combustion products.

### Fabrication and heat treatment

More fabrication experience has been accumulated with Type 201 than with other high manganese grades. This steel performs similarly to Type 301. Shop experience shows that brake and draw-bench forming of the two types can be performed with the same brake-die radius and width and the same draw-bench rolls. Equally good results have been obtained with both grades. There is less experience in such operations as spinning, hammer forming, and deep drawing. Possibly, in some cases, Type 202 should be used instead of Type 201 for such forming operations.

For all arc-welding, spot, seam and projection welding, procedures suitable for Type 301 can be used for Type 201. Weldments can be produced with equal ease and of equally high quality. Available data indicate that the soundness, shear, tension, impact and fatigue properties of welds in Type 201 are equal to those made in Type 301.

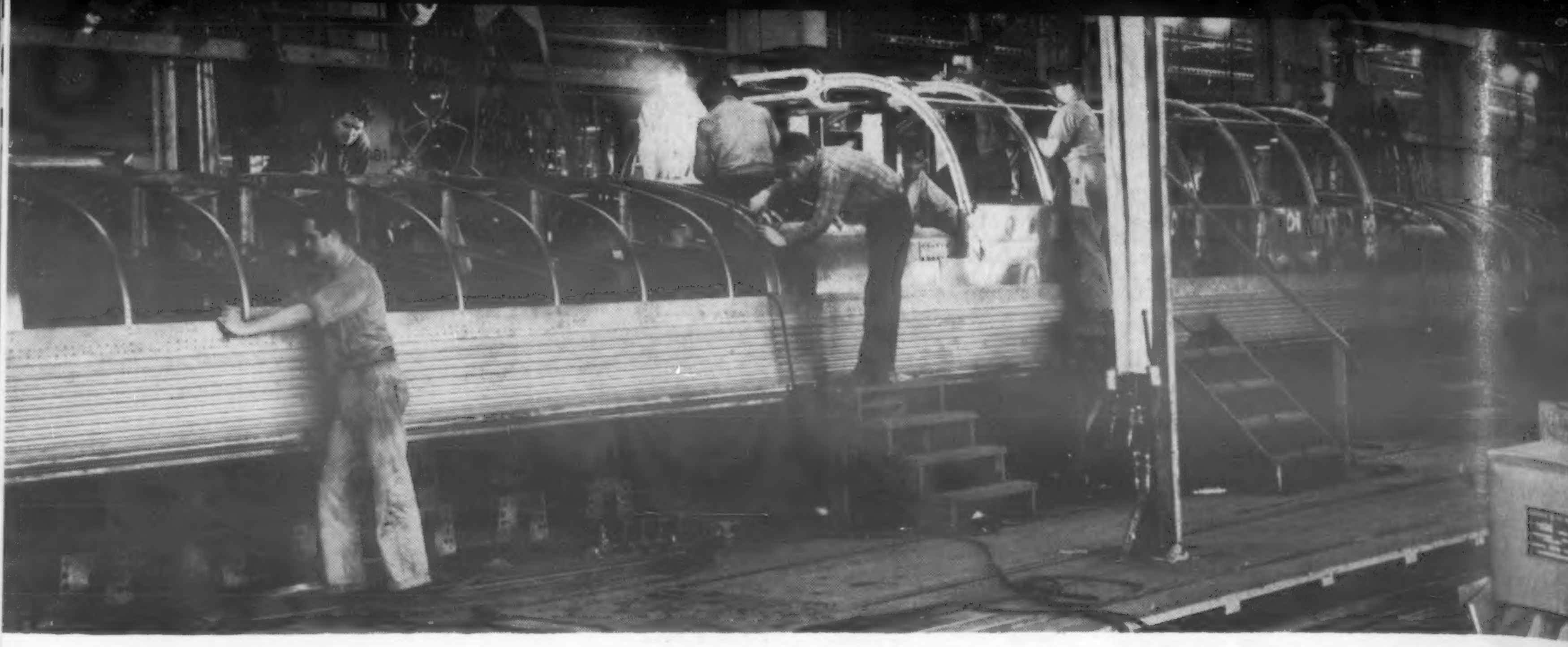
Types 201 and 202 are annealed at 1950-2000F and either air cooled or water quenched. Maximum strength and rupture ductility are obtained in CMN by heating 5 min at 2150F, air cooling, reheating at 1500F for 16 hr, and again air cooling. For service in which elevated-temperature strength requirements are not stringent, G-192 can be used as hot worked. However solution annealing at 2150-2250F considerably increases rupture life. High strength and hardness are obtained by solution annealing at

**TYPICAL TENSILE PROPERTIES OF HIGH-MANGANESE GRADES**

| Designation | Form | Condition | Test Temp, F | Ten Str, 1000 psi | Yld Str, (0.2%) 1000 psi | Elong, % |
|---|---|---|---|---|---|---|
| AISI 201 | Sheet | Annealed | Room | 115 | 55 | 55 |
| | Sheet | ¼ Hard | Room | 125 | 75 | 43 |
| | Sheet | ½ Hard | Room | 150 | 105 | 25 |
| | Bar | Annealed | Room | 114 | 53 | 57 |
| | Bar | Annealed | 1200 | 50 | 21 | 36 |
| | Bar | Annealed | 1400 | 37 | 19 | 38 |
| | Weld | As welded | Room | 102 | 64 | 48 |
| | Weld | As annealed | Room | 95 | 47 | 60 |
| AISI 202 | Sheet | Annealed | Room | 105 | 55 | 55 |
| CMN | Sheet | Ann & Aged | 1200 | 76 | — | 10 |
| | Sheet | Ann & Aged | 1500 | 46 | — | 22 |
| | Casting | | 1600 | 38 | 28 | 8 |
| | Casting | | 1750 | 26 | — | 32 |
| G-192 | Bar | Hot worked | Room | 149 | 84 | 11 |
| | Bar | Hot worked | 1400 | 46 | 31 | 42 |
| | Bar | Hot worked | 1500 | 34 | 25 | 69 |
| | Bar | Hot worked | 1600 | 25 | 19 | 47 |
| | Bar | Annealed | Room | 149 | 86 | 55 |
| | Bar | Annealed | 1000 | 93 | 39 | 29 |
| | Bar | Annealed | 1200 | 69 | 36 | 16 |
| | Bar | Annealed | 1400 | 48 | 34 | 11 |
| | Bar | Annealed | 1600 | 31 | 26 | 25 |
| | Bar | Ann & Aged | 1000 | 96 | 41 | 33 |
| | Bar | Ann & Aged | 1200 | 73 | 37 | 16 |
| | Bar | Ann & Aged | 1400 | 51 | 35 | 26 |
| | Bar | Ann & Aged | 1600 | 33 | 26 | 26 |

**TYPICAL RUPTURE PROPERTIES OF HIGH-MANGANESE GRADES**

| Designation | Form | Condition | Test Temp, F | Rupture Stress, 1000 psi | |
|---|---|---|---|---|---|
| | | | | 100 hr | 1000 hr |
| AISI 201 | | Annealed | 1200 | — | 21.0 |
| | | Annealed | 1400 | — | 7.0 |
| CMN | Sheet | Ann & Aged | 1000 | 80.0 | 74.0 |
| | Sheet | Ann & Aged | 1100 | 65.0 | 55.0 |
| | Sheet | Ann & Aged | 1200 | 45.0 | 35.0 |
| | Sheet | Ann & Aged | 1350 | 25.0 | 18.0 |
| | Sheet | Ann & Aged | 1500 | 13.0 | 10.0 |
| | Casting | Ann & Aged | 1600 | 10.0 | — |
| G-192 | Bar | Hot worked | 1350 | 18.0 | — |
| | Bar | Hot worked | 1500 | 7.4 | — |
| | Bar | Hot worked | 1600 | 3.9 | — |
| | Bar | Annealed | 1200 | 42.0 | — |
| | Bar | Annealed | 1350 | 27.3 | 16.0 |
| | Bar | Annealed | 1500 | 14.7 | 8.0 |
| | Bar | Annealed | 1600 | 9.9 | 5.1 |
| | Bar | Ann & Aged | 1200 | 42.2 | — |
| | Bar | Ann & Aged | 1350 | 27.7 | 17.5 |
| | Bar | Ann & Aged | 1500 | 13.7 | 5.9 |
| | Bar | Ann & Aged | 1600 | 8.5 | 2.5 |



***Railroad passenger cars** can be sheathed with chromium-manganese stainless steels as readily as with chromium-nickel grades.*
*(The Budd Mfg. Co.)*

***Teakettle jacket and mixing bowl** (rear) produced from 0.020-in. gage Type 202 with a single draw and no anneal. In foreground are a shoe fastener (left) formed from 1/4 to 1/2 hard Type 201 and a combination lock cover from Type 202.*
*(Allegheny-Ludlum Steel Corp.)*

***Burner supports** for electric ranges show slight differences in embossing between 201 (left) and 301 because of greater stiffness of 201. Cutting dies slightly deeper when working 201 overcomes the difficulty.*
*(Stainless Steel Committee, AISI)*

**CORROSION DATA ON HIGH-MANGANESE GRADES IN. PENETRATION PER MONTH**

| Designation | 201 | 301 | 202 | 202 Heliarc Weld | 304 |
|---|---|---|---|---|---|
| Boiling 65% nitric acid, five 48-hr exposures | 0.0017 | 0.0015 | 0.0015 | — | — |
| Boiling 1% copper sulfate, 8% sulfuric acid, 72-hr test | 0.00003 | 0.00002 | — | — | — |
| Air-saturated 5% lactic acid, 86 F, 96-hr test | 0.00001 | 0.00001 | — | — | — |
| Air-saturated 10% phosphoric acid, 86 F, 96-hr test | 0.00001 | 0.00001 | — | — | — |
| Air-saturated 60% acetic acid, 158 F, 96-hr test | 0.00001 | 0.00001 | — | — | — |
| Boiling 50% phosphoric acid five 4-hr exposures | — | — | 0.0003 | 0.0001 | 0.0001 |
| Boiling 15% glacial acetic acid, five 4-hr exposures | — | — | 0.0000 | 0.0001 | 0.0000 |
| Boiling 15% lactic acid, five 4-hr exposures | — | — | 0.0000 | 0.0000 | 0.0000 |
| Boiling 25% (by wt) citric acid, five 4-hr exposures | — | — | 0.0000 | 0.0000 | 0.0000 |
| Boiling 30% (by wt) tartaric acid, five 4-hr exposures | — | — | 0.0000 | 0.0000 | 0.0000 |

*Note: Tests made on 0.050 to 0.125-in. x 2-in. specimens sheared from annealed sheet; ground on 120 grit paper; washed in soap and water; degreased in acetone; cleaned 20 min in 20% nitric acid at 140 F.*

2150F, aging 16 hr at 1400F and air cooling.

**Applications**

Experience indicates that Type 201 can substitute for Type 301, while Type 202 can be substituted for Type 302, at least so far as strength and formability characteristics are concerned. Likewise, it seems safe to substitute the 200 series steels for their 300 series counterparts where corrosion conditions are mild (i.e., atmospheric corrosion) or mild to moderate. Under more severe corrosion conditions suitable laboratory or field tests should precede and guide the substitution.

CMN was developed for annealing furnace rider sheets, but can be used for a variety of furnace parts in either cast or wrought


***Basins** for group wash fountains produced from Type 202 are drawn to depth, have the edges curled and are machined with the same procedures used when forming Type 302.* *(Stainless Steel Committee, AISI)*

form. In the rider-sheet application it is a substitute for AISI Types 310 and 446 and is reported to outperform 446 by a wide margin.

G-192 was developed as an alloy of low strategic-alloy content for elevated temperature use. A specific application is internal combustion engine exhaust valves.

**Experimental Cr-Mn-N Stainless Steels**

Other nickel-free austenitic stainless steels of high manganese and nitrogen contents, are under development. U. S. Steel is working on a nickel-free substitute for Type 301 having about 0.10 carbon, about 18 chromium, 15 manganese, and 0.40% nitrogen. Proper adjustment of chemical composition, particularly manganese and chromium, permits pouring sound ingots with nitrogen contents as high as 0.65%.

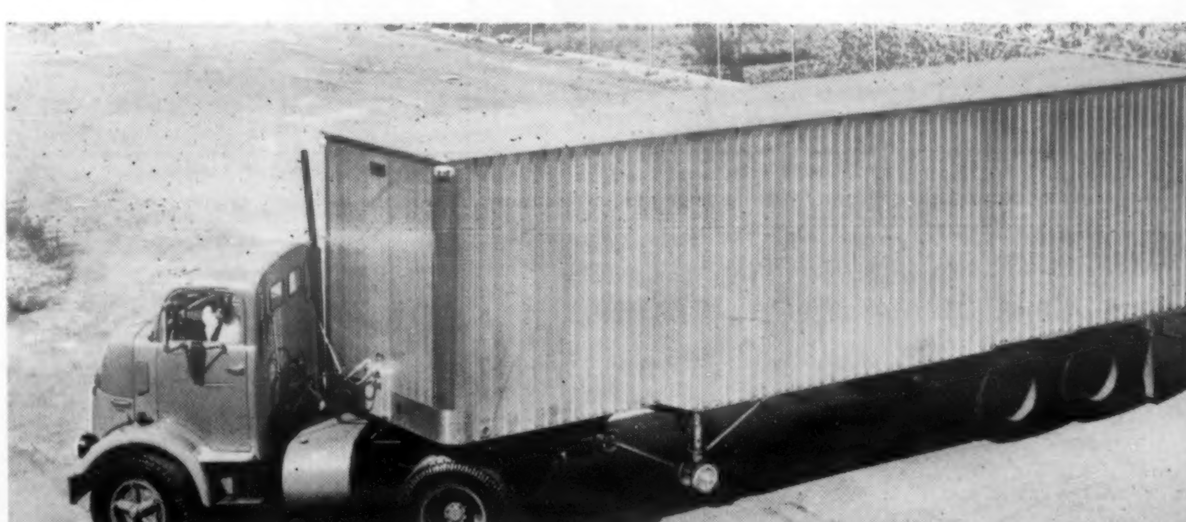
Ford Motor Co. is working on a high nitrogen, chromium-manganese austenitic steel for high temperature service. A composition approximately 16Cr-14Mn-2Mo-½%N, shows creep-rupture properties equivalent to those of the commercial alloy, 16-25-6, at 1200 to 1400F.

Standard Oil of Indiana has been investigating steels containing 21 to 33% Cr and has found that, with high-carbon and high-nitrogen contents, such steels can be made completely austenitic at 2200F and higher.

# Extra-Low-Carbon Grades

Two extra-low carbon grades of wrought stainless steel are recognized by the AISI. One is an 18-8 steel (304L) and the other an 18-8 type containing molybdenum (316L). In addition, the high alloy foundry industry regularly produces two similar grades of extra-low carbon casting alloys. These grades carry the Alloy Casting Institute designation, CF-4 and CF-4M, on an informal basis. In the immediate future, the ACI plans to formalize designations for casting grades of very low carbon alloys to conform with the practice of the casting industry.

It should be remembered that chemical composition ranges for casting grades of stainless-type alloys are not the same as those of wrought alloys, even in types that are nominally counterparts of one another. The difference is dictated by the special metallurgical problems of a stainless



***Trailer bodies** are one of the outstanding uses of the 200 series at present.* *(U. S. Steel Corp.)*

**COMPOSITION OF EXTRA-LOW-CARBON GRADES**

| Designation | C | Mn | Cr | Ni | Mo |
|---|---|---|---|---|---|
| AISI 304L | 0.03 max | 2.00 max | 18/20 | 8/11 | — |
| AISI 316L | 0.03 max | 2.00 max | 16/18 | 10/14 | 1.75/2.50 |
| ACI CF-4[1] | [2] | 1.50 max | 18/21 | 9/12 | — |
| ACI CF-4M[1] | [2] | 1.50 max | 18/21 | 10/13 | 2/3 |

[1] *Informal designation*
[2] *Approximately 0.03% or less*

**TYPICAL ROOM-TEMPERATURE PROPERTIES OF EXTRA-LOW-CARBON GRADES**

| Designation | Form | Cond | Ten Str, 1000 psi | Yld Str, (0.2%) 1000 psi | Elong, % |
|---|---|---|---|---|---|
| AISI 304L | Sheet | Ann | 82 | 35 | 56 |
| CF-4[1] | Casting | Ann | 79 | 34 | 71 |
| AISI 304 | Sheet | Ann | 92 | 40 | 55 |
| AISI 316L | Sheet | Ann | 80 | 38 | 58 |
| CF-4M | Casting | Ann | 79 | 37 | 50 |
| AISI 316 | Sheet | Ann | 85 | 48 | 43 |

*Results of relatively few tests.*

**CHARPY KEYHOLE IMPACT DATA, FT-LB, EXTRA-LOW-CARBON GRADES**

| Designation | Condition | Test Temperature, F | | |
|---|---|---|---|---|
| | | 75 | —105 | —320 |
| AISI 304L | ½ hr-1950F-W.Q. | 65 | 60 | 56 |
| | 100 hr-1600F | 65 | 61 | 55 |
| | 2 hr-1200F | 63 | 60 | 52 |
| AISI 316L | ½ hr-1950F-W.Q. | 68 | 61 | 57 |
| | 100 hr-1600F | 48 | 38 | 28 |
| | 2 hr-1200F | 69 | 62 | 59 |

**TYPICAL CREEP DATA FOR WROUGHT EXTRA-LOW-CARBON GRADES**

| Designation | Temp, F | Stress, 1000 psi, for Creep Rate of 1% in 10,000 hr |
|---|---|---|
| AISI 304L | 1100 | 8.3 |
| | 1200 | 6.3 |
| | 1300 | 4.0 |
| | 1400 | 2.0 |
| AISI 304 | 1100 | 11.8 |
| | 1200 | 7.8 |
| | 1300 | 5.0 |
| | 1400 | 3.0 |
| AISI 316L | 1100 | 12.6 |
| | 1200 | 8.4 |
| | 1300 | 4.4 |
| | 1400 | 1.7 |
| AISI 316 | 1100 | 19.0 |
| | 1200 | 12.5 |
| | 1300 | 8.0 |
| | 1400 | 4.8 |

foundry and of alloys used in the cast condition. The customer is advised, therefore, to use wrought alloy designations when he wants wrought material, and ACI designations when he wants castings.

Extra-low carbon grades are either warehoused or are readily available from a number of producers in a wide variety of forms including sheet and strip, bar, flats and plate, seamless or welded tubing, and a wide assortment of castings.

## Mechanical properties

As expected, the very low carbon 304L stainless steel is weaker than the higher carbon Type 304. Its average tensile strength is about 10,000 lower, while its average percentage elongation is about the same. Likewise, the low carbon molybdenum-containing Type 316L is weaker than the higher carbon Type 316. The average tensile strength of Type 316L is about 5000 psi lower, its average yield strength about 10,000 psi lower, and its average percentage elongation is about 5% higher. Available data indicate that the strength and ductility of the very low carbon casting grades are about the same as those of their higher carbon counterparts, i.e., CF-8 and CF-8M.

The notched-bar impact properties of the low carbon wrought 18-8 type steel are good and are relatively insensitive to temperature and to prior heat treatment. However, the impact properties of Type 316L are decreased by heating 100 hr at 1600F and, after this treatment, they are sensitive to the test temperature. It is probable that sigma phase formation in the molybdenum-containing alloy during the 1600F treatment accounts for the decrease in impact strength.

Creep strengths of the extra-low carbon wrought grades appear to be somewhat lower than the average values for their higher carbon counterparts in the 1100 to 1400F range. Creep and rupture properties of the very low carbon casting alloys are about the same as those of their higher

carbon counterparts.

### Corrosion resistance

Extra-low carbon grades were developed to provide austenitic stainless steels of superior resistance to intergranular corrosion. The susceptibility of the stainless steel to intergranular attack is related to the presence of chromium carbides at the grain boundaries of the metal. One way to reduce the incidence of these carbides and, hence, increase resistance to attack is to decrease the carbon content of the metal.

In ordinary higher carbon grades of austenitic stainless steel, chromium carbides precipitate in the grain boundaries when the metal is heated in the range 800 to 1600F. During welding, an area of parent metal adjacent to the weld will inevitably be heated into this range, chromium carbides will precipitate and the region will be *sensitive* to intergranular attack.

In many media such precipitated carbides do not limit the usefulness of the metal. In others, they do. Although the carbides can be redissolved by annealing after welding, such a step is frequently out of the question, and it may be desirable to use an extra-low carbon grade.

Generally speaking, Types 304L and CF-4 are used in moderate to severe media at service temperatures below the *sensitizing range* in applications where Types 304 and CF-8 aren't quite good enough in resistance to intergranular attack and post-weld annealing is impractical. On the other hand, if the equipment is

**TYPICAL CREEP AND RUPTURE DATA FOR EXTRA-LOW-CARBON CASTING GRADES**

| Designation | Temp, F | Rupture Str, 1000 psi | | Stress, 1000 psi, for Creep Rate of: | |
|---|---|---|---|---|---|
| | | 100 hr | 1000 hr | 1% in 100 hr | 1% in 1000 hr |
| CF-4 | 1000 | 38 | 31 | 36 | 32 |
| | 1200 | 19 | 15 | — | 9.6 |
| | 1400 | 9.1 | 6.4 | — | 4 |
| CF-4M | 1000 | 47 | 42.5 | 41 | — |
| | 1200 | 25 | 18 | — | 13 |
| | 1400 | 10.7 | 7.2 | 6.5 | 3.4 |

complicated and assembly by welding requires keeping it hot for some time or it is used in the sensitizing range a columbium- or titanium-stabilized grade is commonly used.

It should be noted that the "L" grades are not completely immune to intergranular attack. These grades can become susceptible after prolonged heating in the sensitizing range especially at such temperatures as 1000 to 1300F.

Addition of molybdenum raises the corrosion resistance of 18-8 to a variety of media such as sulfurous, sulfuric, phosphoric, formic and various hot organic acids. It makes 18-8 useful at room temperature in sulfuric acid of concentrations up to 15%, and higher than 85%. It substantially increases resistance to pitting, which is particularly important in media containing halogen ions and also imparts high temperature strength.

As in the case of the molybdenum-free 18-8 grades, Type 316L is used instead of Type 316 where extensive welding is in order. Like Type 304L it resists harmful carbide precipitation from the welding heat, but if used continuously at temperatures of 800 to 1600 F will be sensitized.

### Fabrication and heat treatment

Generally speaking, the "L" grades are fabricated and heat treated in the same manner as their higher carbon counterparts. They are readily cold formed and welded. They are annealed by heating in the range of 1800-2000 F followed by a water quench.

### Applications

The use pattern of the "L" grades has been indicated above. Specific applications of the molybdenum-free type include evaporators, fractionating towers for organics, heat exchangers and superheaters, filters, stills, condensers, and tanks. The molybdenum-containing grade finds use in sulfate pulp and paper production, handling of sulfurous, sulfuric, phosphoric, formic and acetic acids, distillation, fractionating, manufacture of various resins, reactors for ammonia and sulfuric acid.

## Wrought Precipitation-Hardenable Grades

A few years ago, the combination of high strength and corrosion resistance in standard chromium-nickel stainless steels could be produced only by cold working. However, development of a series of grades which can be hardened by a simple heat treatment has extended the field of application of these materials. Composition of precipitation hardenable steels are tabulated.

These precipitation-hardenable stainless steels can be grouped into three basic classes, as follows:

Class 1—Those which are hardened by precipitation from a martensitic matrix alone (Stainless W and 17-4PH).

Class 2—Those which are hardened by a combination of transformation of austenite to martensite and precipitation from the martensitic matrix (17-7PH and AM350).

Class 3—Those which are hardened by precipitation from an

austenitic matrix alone (17-10P, 17-14 Cu-Mo, and HNM).

17-7PH is available in annealed or cold-rolled coils and cut lengths of sheet and strip, and in cold-rolled plate, as forging billets, bars, wire rod, and drawn wire within standard size limits. 17-4PH is available in bars, rod, wire, and forging billets, but not in sheet or strip. AM350 is available in plate, bar, rod, sheet, strip, and wire. Stainless W can be produced in the same shapes and sizes as 17-7PH and 17-4PH.

17-14 Cu-Mo can be produced in plate, sheet, strip, forging billets, bar, and wire in all regular stainless steel gages and sizes. Plate, sheet and strip can be supplied in the annealed or cold-rolled conditions, but not in the aged condition. 17-10P is currently produced in billet, bar, and wire form. It is supplied only in the annealed condition. Since HNM is a new alloy, the shapes in which it is available are not yet known.

## Mechanism of Precipitation Hardening

**Class 1—Martensitic alloys**

The martensitic alloys are severely unbalanced AISI 301 types, which are austenitic at the annealing temperature. The precipitation-hardening phases are soluble in this austenite. Upon cooling to room temperature, the austenite transforms to martensite. The precipitating phases are not soluble in martinsite but are held in supersaturated solid solution at these temperatures. Upon aging at 800 to 1100F, precipitation occurs, resulting in noteworthy increases in strength. The element responsible for the prericiptation in Stainless W is titanium, while in 17-4PH, it is copper.

**Class 2—Semiaustenitic alloys**

In these alloys, the precipitation-hardening phases are soluble in austenite but relatively insoluble in martensite. As annealed the alloys are austenitic and to be hardened, must be transformed into martensite. This can be accomplished by cold work, refrigeration (i.e., cooling to –100F), or treatment at 1400F to precipitate carbon as chromium carbide. Carbide precipitation raises the martensite formation temperature range so that on cooling to 60F, the alloys become essentially martensitic. The alloys are then aged in the range of 750 to 1050F to promote precipitation of the supersaturated phase. In 17-7PH, aluminum is responsible for precipitation hardening. AM350 is not a true precipitation hardening steel but does achieve the same effect and is generally classified as a precipitation-hardenable type.

**Class 3—Austenitic steels**

In the completely austenitic steels the precipitation-hardening phase (carbides) is soluble in the austenitic matrix at annealing temperatures. These carbides are held in solid solution by water or oil quenching to room temperature. Upon aging at 1200 to 1400F the carbides precipitate causing increased hardness and strength. Although carbides are the precipitating phases, in HNM and 17-10P the precipitation-hardening phenomenon is greatly enhanced by the lattice-straining action of phosphorus.

### Mechanical properties

Age-hardenable stainless steels offer a wide range of mechanical and physical properties. Those of the first two classes have excellent strength properties at temperatures up to 800F and are magnetic and martensitic as hardened. The third class does not produce such high room temperature strength properties, but is nonmagnetic and austenitic and has better strength than alloys of the first two classes at temperatures of 1000F and above.

For the most part, the steels within each class are competitive. Martensitic Stainless W and 17-4PH have similar properties which can be developed in either cast or wrought products. They lack the formability, as annealed, of the semiaustenitic and austenitic types. However, they can be hardened by a single heat treatment. Both are marketed to a guaranteed minimum ultimate tensile strength of 185,000 psi.

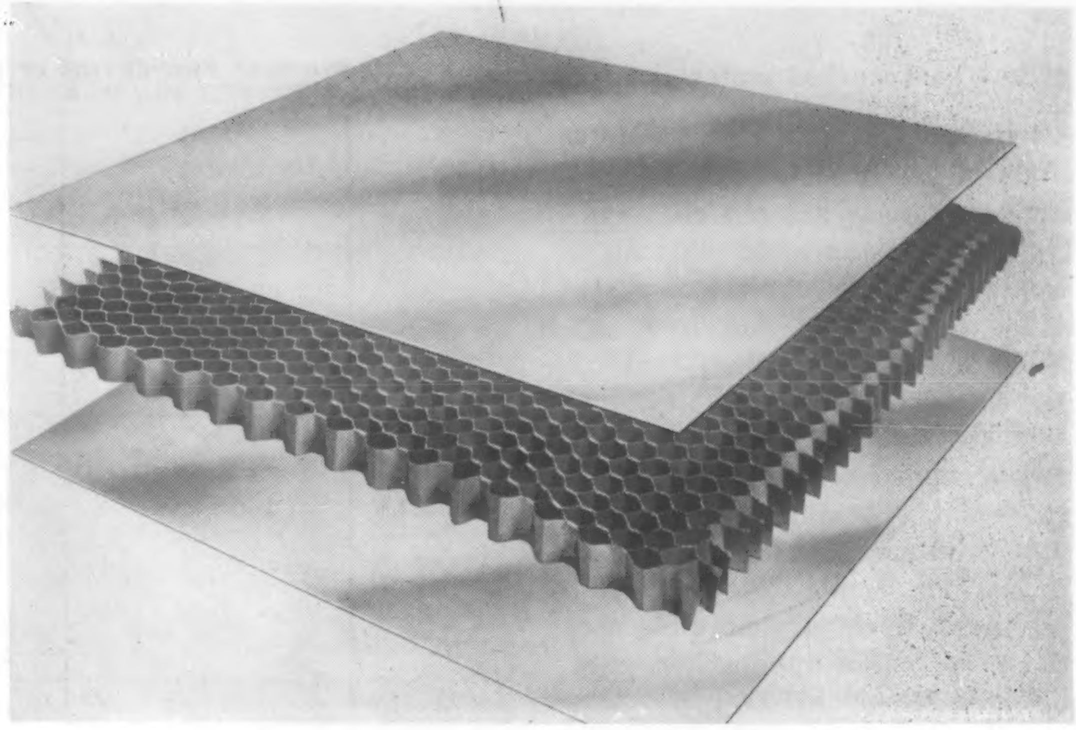
Semiaustenitic alloys have good ductility as annealed and are readily formable. 17-7PH is marketed to a guaranteed minimum tensile strength of 185,000 psi when aged at 950F. However, for certain applications requiring added ductility, aging at 1050F, resulting in somewhat lower guaranteed minimum strength, is recommended. Guaranteed properties for AM350, a relatively new product, have not been established. Since AM350 does not age harden,

**NOMINAL COMPOSITION OF PRECIPITATION-HARDENABLE GRADES**

| Designation | C | Cr | Ni | Other |
|---|---|---|---|---|
| MARTENSITIC TYPES (Class 1) | | | | |
| Stainless W | 0.07 | 17 | 7 | 0.70Ti, 0.20Al |
| 17-4PH | 0.04 | 16.5 | 4 | 4.0Cu, 0.35Cb + Ta |
| SEMIAUSTENITIC TYPES (Class 2) | | | | |
| 17-7PH | 0.07 | 17 | 7 | 1.10Al |
| AM350 | 0.07 | 17 | 4 | 2.75Mo |
| AUSTENITIC TYPES (Class 3) | | | | |
| 17-10P | 0.12 | 17 | 10.25 | 0.25P |
| 17-14 Cu-Mo | 0.12 | 16 | 14 | 2.5Mo, 3Cu, 0.45Cb, 0.25Ti |
| HNM | 0.30 | 19 | 9.5 | 3.5Mn, 0.30P |

it does not develop strength properties as high as those of 17-7PH. However, because of its molybdenum content, it has excellent elevated temperature strength. In both alloys, transformation by refrigeration at −100F produces the optimum combination of properties.

Completely austenitic alloys offer the widest range in properties of the three classes. 17-10P was designed specifically to develop moderate strength (about 140,000 psi) and be nonmagnetic. As annealed it is very ductile and has excellent forming properties. 17-14 Cu-Mo is a special high temperature stainless, economical in price, easy to fabricate and suitable for service up to 1500F. It does not have high room temperature strength. HNM, a new product, develops room temperature strength approaching the martensitic and semiaustenitic types. At temperatures above 1000F, its strength is much superior to that of the other precipitation-hardenable stainless steels and about equal to that of Timken 16-25-6, one of the first so-called superalloys.



***Honeycomb structures** with excellent strength-weight characteristics can be fabricated from Armco 17-7PH. Square cell is resistance welded at the node line, cover sheets are added by brazing and assembly is heat treated to condition TH1050.*

In general, all three classes of precipitation-hardenable stainless steels show uniform properties in both the longitudinal and transverse directions in tension and compression. Exceptions are 17-7PH and AM350 which, when transformed by cold work, will show somewhat lower yield strength in compression than in tension. This, of course, is true

**TYPICAL ROOM-TEMPERATURE MECHANICAL PROPERTIES OF PRECIPITATION-HARDENABLE GRADES**

| Designation | Condition | Ten Str, 1000 psi | Yld Str, 1000 psi | Elong in 2 in, % | Hardness, Rockwell C | Charpy Impact, ft-lb | Endur Limit, 1000 psi |
|---|---|---|---|---|---|---|---|
| MARTENSITIC TYPES | | | | | | | |
| Stainless W | Annealed | 135 | 95 | 7 | 25 | — | — |
| | Aged ½ hr at 950F | 210 | 195 | 7 | 43 | — | 80 |
| | Aged ½ hr at 1050F | 190 | 170 | 8 | 39 | — | — |
| 17-4PH | Annealed | 150 | 110 | 12 | — | — | — |
| | Aged 1 hr at 900F | 195 | 180 | 13 | 43 | 19 | 90 |
| | Aged 1 hr at 1100F | 161 | 155 | 15 | 31 | — | 82 |
| SEMIAUSTENITIC TYPES | | | | | | | |
| 17-7PH | Annealed | 130 | 40 | 30 | $R_b$85 | — | — |
| | Treated at 1400F | 145 | 100 | 9 | 31 | — | — |
| | Aged at 950F | 215 | 200 | 8 | 45 | 6 | 78 |
| | Aged at 1050F | 200 | 185 | 9 | 43 | — | 80 |
| AM350 | Annealed | 186 | 52 | 22 | $R_b$94 | 100 | — |
| | Subzero cooled | 197 | 110 | 12 | 40 | — | — |
| | Tempered at 750F | 199 | 159 | 11 | 41 | 51 | 80 |
| | Tempered at 950F | 189 | 163 | 15 | 41 | 51 | — |
| | Double aged | 169 | 142 | 11.5 | 38 | 23 | — |
| AUSTENITIC TYPES | | | | | | | |
| 17-10P | Annealed | 89 | 37.5 | 70 | $R_b$82 | 120[1] | — |
| | Aged | 137 | 88 | 25 | 30 | 40[1] | |
| | Double Aged | 143 | 98 | 20 | 31 | 35[1] | — |
| 17-14 Cu-Mo | Annealed at 2250F and aged | 86 | 42 | 45 | $R_b$80 | 110[1] | — |
| | Annealed at 2050F and aged | 89 | 41 | 45 | — | — | — |
| HNM | Annealed at 2000F: | | | | | | |
| | aged at 1200F | 153 | 110 | 26.5 | 34 | 18 | — |
| | aged at 1300F | 163 | 117 | 21.5 | 35 | 13 | — |
| | aged at 1400F | 154 | 106 | 22.5 | 31 | 18 | — |
| | Annealed at 2100F: | | | | | | |
| | aged at 1200F | 166 | 130 | 18.5 | 40 | 8 | — |
| | aged at 1300F | 180 | 141 | 16 | 36 | 7 | — |
| | aged at 1400F | 169 | 124 | 18 | 40 | 9 | — |

[1] *Izod.*

of any cold worked material.

**Corrosion resistance**

The precipitation-hardenable stainless steels are not outstanding in resistance to corrosion. However, their corrosion resistance is equal to and in many cases much better than that of the 400 series of hardenable stainless steels. Since they are not recommended for applications in corrodents, producers have not published specific corrosion rates in various media. Nevertheless, all these steels are suitable for those corrosive applications met by cold-rolled AISI Type 301. Mention should be made, however, of the attractive corrosion resistance of AM350. This alloy in the fully hardened condition compares favorably with AISI Type 304 stainless in both sulfuric and acetic acid. It is inferior to AISI 304 in nitric acid.

**Fabrication and heat treatment**

The martensitic alloys (17-4PH and Stainless W) in the annealed condition are hard and not readily punched, cut, blanked, or sheared. Only moderate forming operations are recommended. However, because of their relatively high hardness they are somewhat easier to machine than AISI 302.

Both Stainless W and 17-4PH are annealed at 1900F for ½ hr at temperature. The manner of cooling is immaterial, although oil or water quenching may cause cracking. Air cooling from the annealing temperature is usually recommended. Aging for maximum strength is accomplished at 950 ± 10F for 1 hr for Stainless W and at 900± 10F for 17-4PH. Aging for better ductility in Stainless W and 17-4PH is accomplished at 1000± 10F and 1050± 10F, respectively.

The semiaustenitic alloys (17-7PH and AM350) are easily punched, sheared, cut, or blanked, although high-grade tool steel dies are required for punching and blanking operations. Both steels, as annealed, are readily formable by conventional techniques used for Type 302. However the alloys work harden rapidly and severe deep-forming operations require intermediate annealing. Annealed 17-7PH and AM350 have better machining characteristics than annealed Type 302. Both precipitation-hardenable alloys produce chips that break up nicely while Type 302 produces a long stringy chip. Cutting rates are about the same for 17-7PH, AM350, and Type 302. In the hardened condition, both 17-7PH and AM350 are machined with more difficulty and require slower speeds.

Both 17-7PH and AM350 are annealed at 1725 ±25F when transformation by refrigeration is planned. When transformation by double aging (1400F, then 950F) is planned, annealing of 17-7PH at 1950 ±25F is recommended. Annealing in the range of 1900 to 1950F produces maximum ductility in both alloys. Annealing can be accomplished in air or in dry-hydrogen atmos-

**STRESS-RUPTURE PROPERTIES OF PRECIPITATION-HARDENABLE GRADES**

| Designation | Condition | Temp, F | Stress for Rupture in 100 hr: Stress, 1000 psi | 100 hr: Elong in 2 in., % | 1000 hr: Stress, 1000 psi | 1000 hr: Elong in 2 in., % |
|---|---|---|---|---|---|---|
| MARTENSITIC TYPES | | | | | | |
| Stainless W | Aged at 950F | 1000 | 31.5 | — | — | — |
| | | 1200 | 12 | — | — | — |
| 17-4PH | Aged at 900F | 600 | 154 | 2.5 | 148 | 2 |
| | | 700 | 134 | 2 | 130 | 2 |
| | | 800 | 130 | 4 | 89 | 4 |
| | | 900 | 81 | 4 | 48 | 17 |
| SEMIAUSTENITIC TYPES | | | | | | |
| 17-7PH | Aged at 950F | 600 | 170 | 19 | 158 | 17 |
| | | 700 | 130 | 21 | 122 | 24 |
| | | 800 | 110 | 21 | 90 | 23 |
| | | 900 | 78 | 30 | 52 | 40 |
| AM350 | Subzero cooled and tempered | 800 | 164 | — | 161 | 6.5 |
| | | 900 | 107 | — | 99 | 8.5 |
| | | 1000 | 63 | — | 53 | — |
| AUSTENITIC TYPES | | | | | | |
| 17-14 Cu-Mo | Annealed at 2250F, Aged at 1350F | 1050 | 56 | 16 | 49 | 12 |
| | | 1200 | 43 | 10 | 37 | 8 |
| | | 1350 | 26 | 11 | 20.5 | 7 |
| | | 1500 | 16.5 | 7 | 12 | 3 |
| HNM | Annealed at 2000F, Aged at 1400F | 900 | — | — | 91 | — |
| | | 1000 | 86 | — | 72 | — |
| | | 1100 | 67.5 | — | 53 | — |
| | | 1200 | 49 | — | 35 | — |
| | | 1350 | 26 | — | 15.5 | — |
| | | 1500 | 11 | — | — | — |

***Acid and fuel** tank head made of 17-7PH.* *(Armco Steel Corp.)*

**ELEVATED-TEMPERATURE TENSILE PROPERTIES OF AGE-HARDENABLE GRADES**

| Designation | Condition | Temp, F | Ten Str 1000 psi | Yld Str, 1000 psi | Elong, % |
|---|---|---|---|---|---|
| MARTENSITIC TYPES | | | | | |
| Stainless W | Aged at 950F | 80 | 192 | 187 | 13.5 |
| | | 600 | 162 | 156 | 12 |
| | | 800 | 145 | 135 | 13.5 |
| | | 1000 | 94 | 54 | 22.5 |
| 17-4PH | Aged at 900F | 80 | 196 | 182 | 15 |
| | | 500 | 170 | 150 | 10 |
| | | 700 | 158 | 138 | 10 |
| | | 900 | 140 | 110 | 10 |
| | | 1000 | 100 | 75 | 15 |
| SEMIAUSTENITIC TYPES | | | | | |
| 17-7PH | Aged at 950F | 80 | 198 | 180 | 11.5 |
| | | 500 | 182 | 170 | 4 |
| | | 700 | 166 | 152 | 6 |
| | | 900 | 128 | 112 | 6 |
| AM350 | Subzero cooled and tempered | 80 | 200 | 165 | 9 |
| | | 500 | 191 | 132 | 8.5 |
| | | 700 | 190 | 121 | 8.5 |
| | | 900 | 164 | 103 | 7.5 |
| | | 1000 | 105 | 84 | 10.0 |
| AUSTENITIC TYPES | | | | | |
| 17-14 Cu-Mo | Annealed at 2250F, Aged at 1350F | 80 | 86 | 42 | 45 |
| | | 600 | 75 | 30 | 35 |
| | | 900 | 73 | 27 | 35 |
| | | 1200 | 64 | 27 | 30 |
| | | 1350 | 53 | 26 | 29 |
| | | 1500 | 34 | 25 | 29 |
| HMN | Annealed at 2000F, Aged at 1400F | 80 | 154 | 106 | 22.5 |
| | | 1000 | 102 | 74 | 17 |
| | | 1100 | 90 | 72 | 21 |
| | | 1200 | 81 | 69 | 23 |
| | | 1350 | 61 | 54 | 24 |

phere furnaces. Carburizing atmospheres should be avoided and dissociated ammonia is not recommended because of the possibility of nitriding. Air cooling from the annealing temperature is adequate, even for heavy sections.

Both alloys are amenable to transformation by cold work, refrigeration, or 1400F treatment. The latter treatment involves heating to 1400 ±25F for 90 min, followed by cooling to below 60F. Interruptions in cooling to 60F will result in incomplete transformation and reduced properties. Transformation by refrigeration is accomplished by cooling to below −100F for 2 hr. Treatment in the range of −100F to −130F is recommended. This temperature is readily obtained by mixtures of dry ice and acetone.

Maximum strength in 17-7PH is developed by aging at 950 ±10F for 1 hr. Improved ductility with a small sacrifice in strength is developed by aging at 1050 ±10F. Since AM350 does not precipitation harden, temperature control during tempering is not critical. Tempering in the range of 750 to 850F will produce a good combination of properties. Air cooling from the aging or tempering temperature is adequate for both alloys.

The completely austenitic types (17-10P, 17-14 Cu-Mo, and HNM) can be punched, sheared, cut, and blanked in the annealed condition. In severe forming operations, they perform in a manner similar to Type 302. Since they have excellent ductility as annealed, many deep forming operations can be accomplished without intermittent annealing. The machining characteristics of these alloys compare favorably with Type 302.

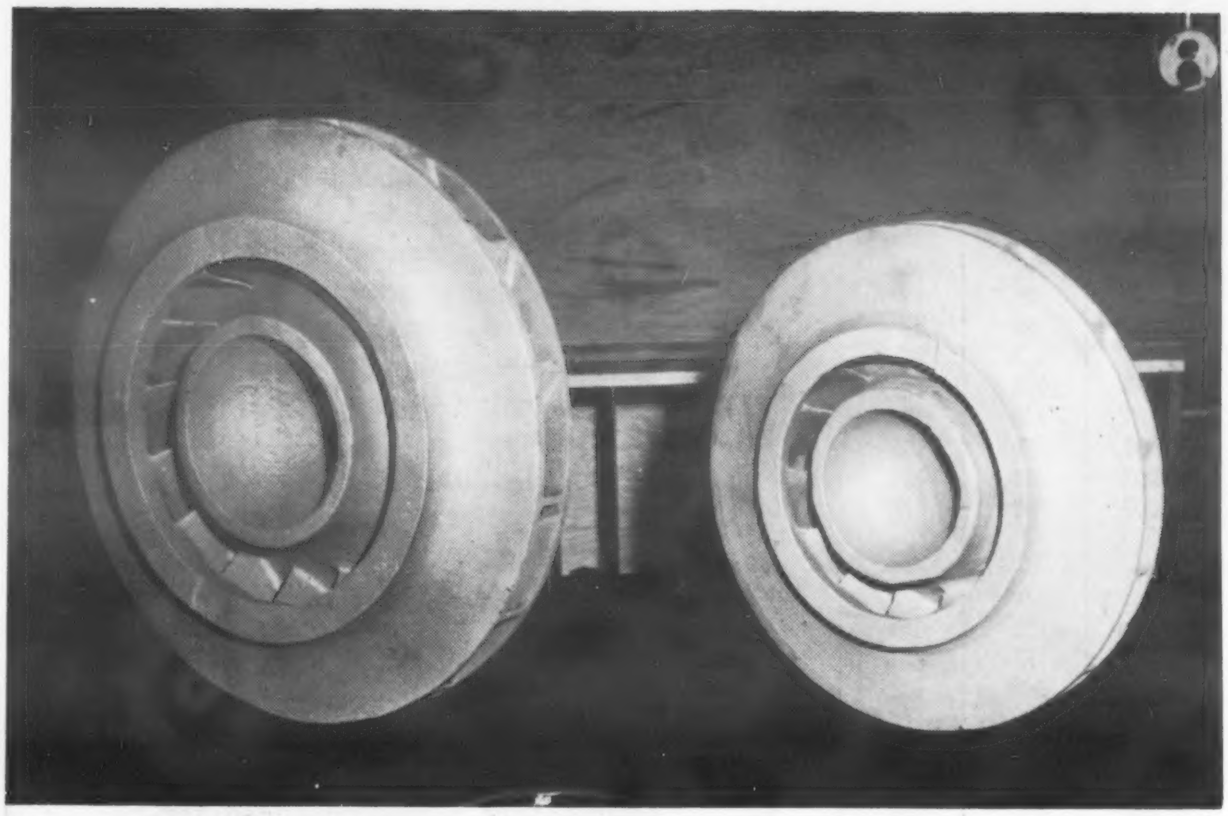
All three alloys are annealed in the relatively high temperature range of 2050 to 2250F. Since annealing temperature affects the solution of carbides (the precipitating phase) a ±25F control of temperature is recommended for consistent properties. All three alloys must be cooled rapidly from the annealing temperature to prevent premature precipitation of carbides. Consequently, quenching in either oil or water is recommended. During annealing, carburizing or nitriding should be avoided.

In the precipitation-hardenable stainless steels, certain dimensional changes occur during heat treatment. In the martensitic and completely austenitic steels this change is due to precipitation alone, and is quite small (about 0.0005 in. per in.). However, the semiaustenitic alloys undergo a growth of 0.0045 in. per in. during transformation in addition to the change of 0.0005 in. per in. during aging. This growth must be taken into account in forming operations.

### Joining

Both the martensitic and semiaustentitic grades are readily weldable by any of the arc and resistance processes applicable to stainless steel. Care must be

***Guided missile frame** stretch formed from 17-7PH and hardened by a low temperature heat treatment.* ***(Armco Steel Corp.)***



***Impellers** of cast 17-4PH are used in corrosive environments for high speed service.*
*(Lebanon Steel Foundry)*

**CHEMICAL COMPOSITION OF CAST PRECIPITATION-HARDENABLE GRADES**

| Designation | C | Cr | Ni | Cu | Si | Mn | Other |
|---|---|---|---|---|---|---|---|
| 17-4PH | 0.07 max | 15.75/16.75 | 3.50/4.25 | 3.50/4.25 | 0.70 max | 0.70 max | N-0.045 max |
| V2B | 0.07 max | 19/19.5 | 9.7/10.24 | 2.0/2.25 | 2.5/3.0 | 0.50/0.75 | Mo-3/3.5 Be-0.1/0.2 |

taken, however, to avoid excessive oxidation of the precipitation promoting phases, particularly titanium in Stainless W and aluminum in 17-7PH. In addition, the alloys must be completely heat treated after welding to retain high strength properties. All alloys of these two types show joint efficiencies of 95 to 100% when fully heat treated after welding but some reduction in ductility of welded sections is often encountered. Aging at a higher temperature (1050F for Stainless W, 17-7PH and 17-4PH) will result in improved ductility with a slight sacrifice in strength.

Of the completely austenitic alloys, only 17-14 Cu-Mo can be successfully welded by the conventional techniques used for stainless steels. Welded specimens of this alloy show somewhat lower stress-to-rupture properties than unwelded specimens. Heat treatment does not noticeably affect the strength of welded joints. The high phosphorus content of 17-10P and HNM makes these alloys very difficult to weld and neither has been successfully welded.

Relatively little information on brazing characteristics is available. However, 17-7PH, 17-4PH, and AM350 can be successfully brazed. For best results, the flow temperature of the brazing alloy should coincide with the annealing temperature to obtain full strength properties after heat treatment.

### Pickling and cleaning

Precipitation-hardenable grades scale during all oxidizing heat treatments. This scale can be removed by pickling or vapor blasting using conventional procedures. A recommended procedure for pickling these alloys consists of scale softening in sodium hydride followed by dipping in a 10% nitric acid—2% hydrofluoric acid solution.

### Applications

The martensitic and semiaustenitic alloys are competitive. Their applications range from small cantilever springs and sawblades to large structural plates in wind tunnels. They have been used as plates, bar, rod, forgings, sheet, strip, and wire in a variety of applications. Because of their high strength-to-weight ratio and good strength at moderate temperatures, they have found wide usage in the aircraft materials program.

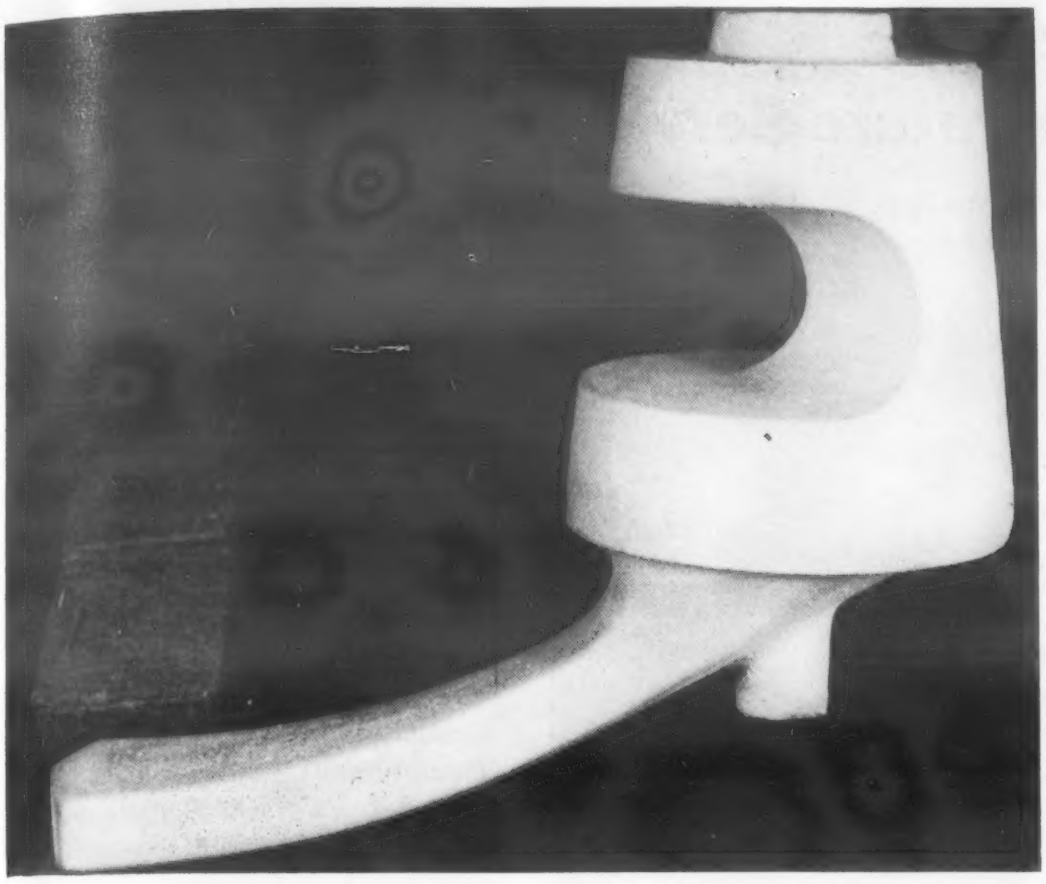
The completely austenitic alloys have found a somewhat different use pattern. The principal use of 17-10P has been in naval programs where moderate strength and low magnetic permeability are a necessity. It has been substituted for K-Monel and beryllium copper with a considerable savings in cost and critical metal. 17-14 Cu-Mo and HNM have excellent strength properties at temperatures above 1000F and, consequently, they have been suggested for use in aircraft gas turbines, high temperature steam turbines, boilers, superheaters, petroleum cracking stills, etc.

### Cast precipitation-hardenable grades

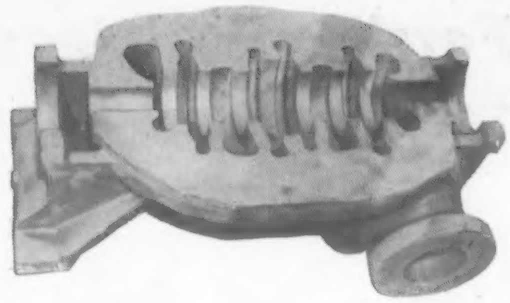
Two cast precipitation-hardenable grades have gained commercial importance, Armco's 17-4PH and Cooper Alloy Foundry's V2B. Others, such as Stainless W, 17-10P, and 17-14 Cu-Mo, have been supplied in the form of castings but have not been produced in large quantities as yet.

**MECHANICAL PROPERTIES OF CAST 17-4PH**

| | Anneal. | Hard. |
|---|---|---|
| Ten str, 1000 psi | 152 | 179 |
| Yld str, 1000 psi | 83 | 150 |
| Elong, % | 5 | 4 |
| Red of Area, % | 8 | 7 |
| Hardness, $R_c$ | 34 | 41 |
| Impact, Izod | 27 | 17 |



**Sanitary valve** *shell cast from 17-4PH.* *(Electric Steel Foundry Co.)*



**Centrifugal pump casing** *cast from PH55A alloy for service in contaminated river water.* *(Cooper Alloy Corp.)*

**Impeller** *cast from 17-4PH for subsequent hardening by heat treatment.* *(Electric Steel Foundry Co.)*

*Armco 17-4PH* — This is the cast version of the wrought alloy previously discussed. Copper is responsible for precipitation hardening.

Room-temperature mechanical properties of cast 17-4PH are appreciably lower than those which can be developed in wrought 17-4PH but these properties are noteworthy for a cast material.

Heat treatment consists of annealing at 1800 to 1850F for 1 hr and cooling to room temperature. Air cooling is adequate. The alloy in this condition is readily machinable. It is hardened by aging at 850-900F for 1 hr followed by air cooling. A slight dimensional change (about 0.0005 in. per in.) occurs on aging. Aging produces only a slight discoloration which can be readily removed by a short pickle in warm dilute nitric acid.

The alloy is readily weldable by any of the conventional methods used for welding standard stainless steels. A 17-4 welding rod is available for such operations. No intergranular corrosion embrittlement results from welding but joints must be heat treated to produce full strength.

The alloy has good corrosion resistance, especially to seawater corrosion and pitting, and is recommended for use in ship propellers, pump impellers, and other marine applications of a wide variety. In food and chemical industries its use in any mildly corrosive application is recommended where strength and galling resistance are required.

*Cooper alloy Type V2B*—V2B is a precipitation-hardenable 18-8 type containing copper, molybdenum, silicon, and a small amount of beryllium which is responsible for age hardening. The alloy was designed to give corrosion resistance, approaching that of Type 316, combined with good strength and galling resistance.

Although this alloy does not develop quite the high strength of cast 17-4PH, it does not overage and lose hardness at elevated temperatures. It maintains a Brinell hardness above 300 at temperatures to 1400F for periods in excess of 50 hr at temperature.

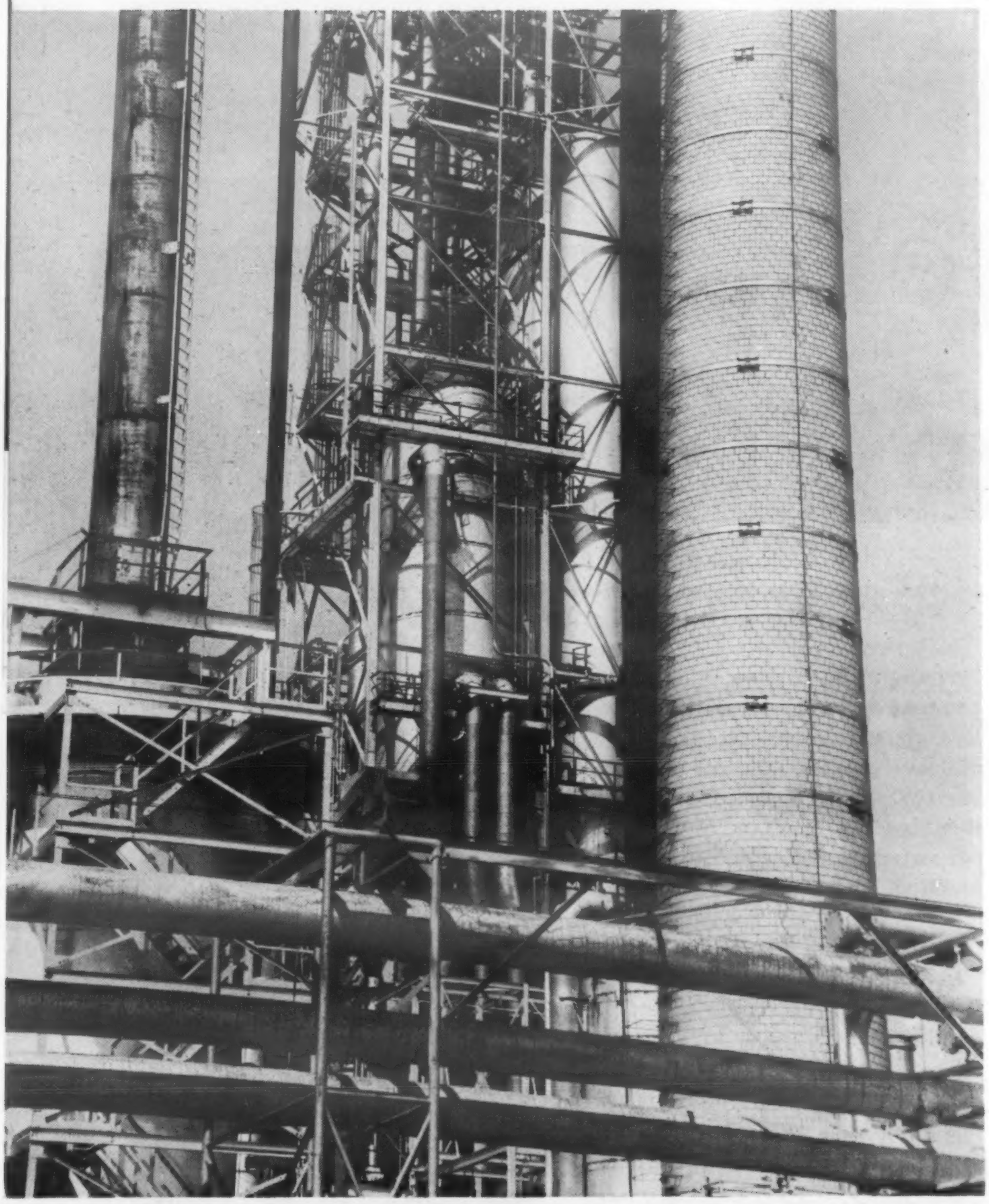
V2B is annealed by water quenching from 2000F. As annealed, the alloy is readily machinable. It is hardened by aging at 925F for 8 hr followed by air cooling. The slight discoloration occuring during aging can be readily removed by a short pickle in a dilute nitric-hydrofluoric acid mixture. In the annealed condition, the alloy is readily weldable using a special V2B welding rod.

V2B combines good strength with excellent corrosion resistance and is, therefore, recommended for such applications as valve disks, shaft sleeves, impellers, pump casings, bearing rings, conveyer links, and other parts requiring wear, galling, and corrosion resistance.

**MECHANICAL PROPERTIES OF V2B**

| | Anneal. | Hard. |
|---|---|---|
| Ten str, 1000 psi | — | 152 |
| Yld str, 1000 psi | — | 122 |
| Elong, % | — | 3 |
| Red of Area, % | — | 2 |
| Hardness, BHN | 269 | 363 |

# Ferritic Stainless Steels for Elevated Temperature Service



***Straight chromium stainless steels** are widely used for elevated temperature service in the petroleum industry.* *(U. S. Steel Corp.)*

**TYPICAL COMPOSITIONS OF FERRITIC STAINLESS STEELS FOR HIGH-TEMPERATURE APPLICATIONS**

| Designation | Producer | C | Mn | Si | Cr | Ni | Mo | V | Cb | W |
|---|---|---|---|---|---|---|---|---|---|---|
| Rex 448 | Firth Vickers, Ltd. | 0.12 | 0.92 | 0.16 | 11.3 | 0.25 | 0.81 | 0.18 | 0.60 | — |
| H 46 | Wm. Jessop & Sons, Ltd. | 0.15 | 0.57 | 0.40 | 11.5 | — | 0.45 | 0.30 | 0.25 | — |
| 422 | Crucible Steel Co. | 0.23 | 0.87 | 0.14 | 13.2 | 0.70 | 1.01 | 0.25 | — | 1.02 |
| 422 M | Crucible Steel Co. | 0.28 | 0.84 | 0.24 | 11.8 | 0.20 | 2.24 | 0.49 | — | 1.72 |

During the past few years, the increasing needs of the aircraft industry for ferritic materials to withstand high stress at temperatures up to and including 1100F have resulted in the appearance of modified 400 series stainless steels. These steels are commonly known as high-temperature ferritic stainless steels although, in reality, they are modified martensitic alloys. They possess a good combination of oxidation resistance and strength with a low thermal coefficient of expansion and low strategic alloy content.

These steels contain chromium in the range of 11 to 13% along with minor amounts of molybdenum, vanadium, tungsten, and columbium. The carbon content varies from about 0.10 to 0.30% and this wide range accounts for substantial differences in properties of various alloys. All these steels are air hardening, even in fairly heavy sections.

The additions of vanadium, molybdenum, tungsten, and columbium impart added resistance to tempering. These additions form complex carbides but since these elements diffuse slowly, growth of stable carbides is slow. Thus, softening is greatly retarded, and the alloys maintain good hardness and strength after relatively high temperature tempering. They exhibit good stress-rupture properties at temperatures up to about 1100F.

Many alloys of this type have been developed. The compositions of four alloys, representative of the range in properties obtainable in these ferritic steels, are tabulated. The steels are generally available on special order in the form of rod, bar, plate, strip, sheet and forgings.

## Mechanical properties

The alloys show considerable variation in short-time elevated temperature strength. Relatively high carbon 422M shows a tensile strength of 238,000 at 800F after tempering at 800F. Low carbon H46 (0.15% C) has an ultimate strength of about 100,000 psi at this temperature but maintains

good strength (69,000 psi) at 1110F. At temperatures above 800F, however, stress-rupture properties are more important than short-time properties and here these steels show their true merit. At 1100F, the 1000-hr rupture properties of these steels are noteworthy (35,000 to 40,000 psi) and are considerably above those of standard austenitic stainless steels and precipitation-hardening martensitic and semiaustenitic stainless steels. Of the stainless alloys, only HNM and Timken 16-25-6 alloy surpass these ferritic steels in strength at 1100F.

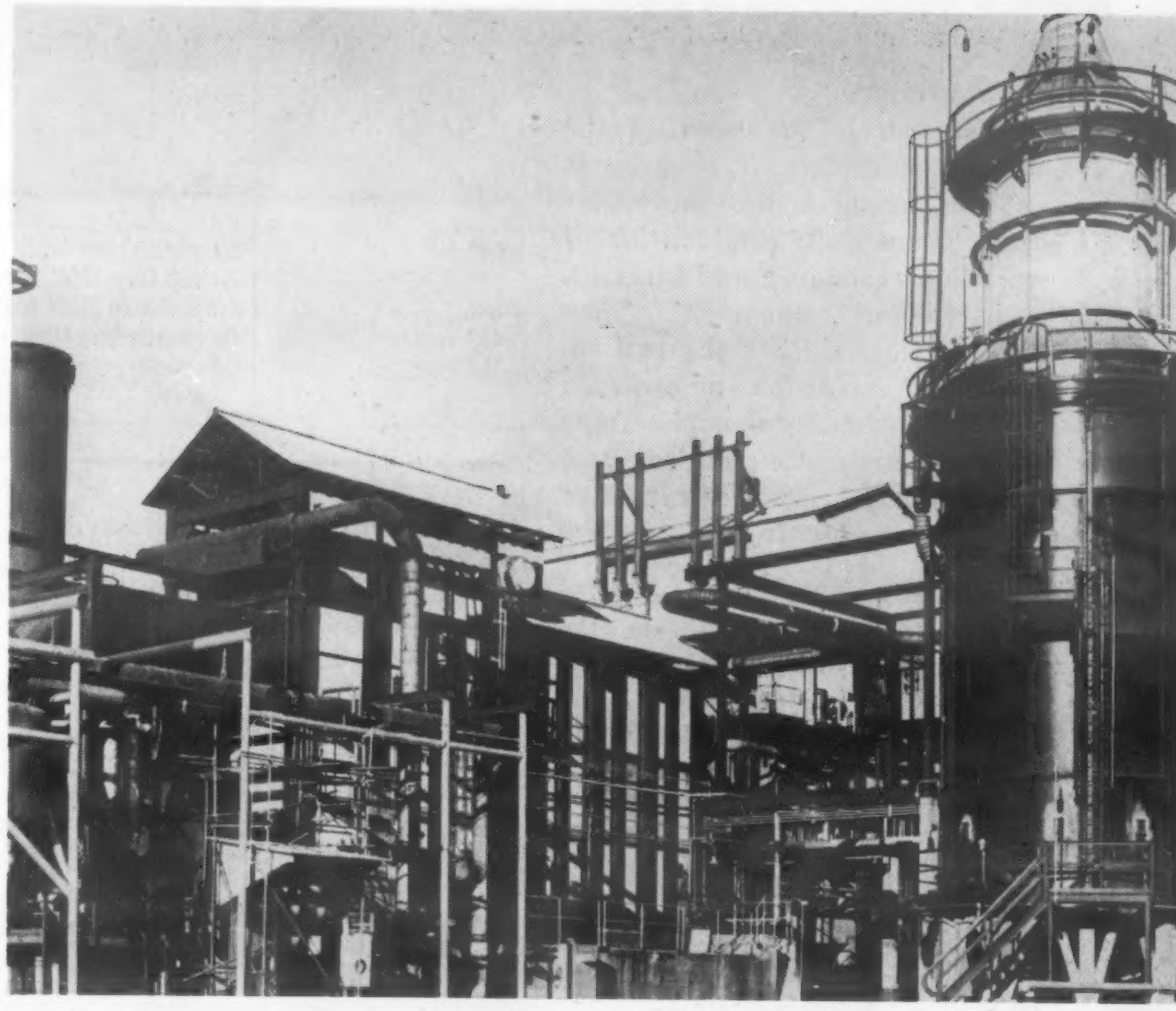
### Heat treatment and fabrication

These ferritic stainless steels are heat treated like the engineering steels. Because of difficulty in dissolving stable carbides, austenitizing temperatures above 1800F are used and temperature has a considerable effect on the properties. Thus, considerably better strength properties are obtained after quenching Rex 448 from 2100F than after quenching from 1850F because of increased solution of carbides at the higher temperature. Care must be taken to prevent decarburization, particularly in the higher carbon steels.

Since these alloys are sufficiently deep hardening, air cooling from the austenitizing temperature is adequate. The relatively high martensite transformation temperature (600F) of the low carbon steels minimizes the possibility of quench cracking. This is not true of the higher carbon steels which are sensitive to quench cracking. Tempering involves no particular difficulties. Temperatures in the range of 800 to 1200F are normally used.

Standard pickling techniques used for the Type 410 steels are adequate for these steels, a 10% nitric acid-1% hydrofluoric acid solution is recommended. Buffing or polishing is necessary to produce the appearance commonly associated with stainless steels.

The low carbon steels (those containing 0.15% carbon and less) are readily weldable. They do not require preheat. However, post-heat at temperatures as high as 1100F is desirable. The higher carbon alloys are much more difficult to weld. They require both preheat and post heat.



***Butane dehydrogenation installation** has lines (operating at 1100 F) to catalyst harps lined with Type 410 stainless steel for heat and corrosion resistance.* *(U. S. Steel Corp.)*

**ELEVATED-TEMPERATURE TENSILE PROPERTIES OF FERRITIC STAINLESS STEELS**

| Designation | Condition | Temp, F | Ten Str, 1000 psi | Yld Str, 1000 psi | Elong, % | Red in Area, % | Charpy Impact, ft-lb |
|---|---|---|---|---|---|---|---|
| H 46 | Air cool from 2100F, temper at 1150F | 390 | 117 | 94 | 17.5 | 32 | — |
| | | 750 | 101 | 82 | 15 | 31 | — |
| | | 930 | 74 | 89 | 15.5 | 33 | — |
| | | 1110 | 69 | 55 | 19 | 41 | — |
| 422 | Oil quench from 1900F, temper at 800F (47$R_c$) | 400 | 227 | 160 | 12 | 43 | 38 |
| | | 600 | 237 | 145 | 13 | 27 | 34 |
| | | 800 | 223 | 140 | 15 | 32 | 28 |
| | Temper at 1100F (36 $R_c$) | 400 | 151 | 125 | 16 | 52 | 53 |
| | | 600 | 141 | 120 | 12 | 47 | 54 |
| | | 800 | 121 | 100 | 14 | 52 | 54 |
| 422 M | Oil quench from 1900F, temper at 800F (50 $R_c$) | 400 | 253 | 180 | 11 | 36 | 27 |
| | | 600 | 252 | 155 | 13 | 37 | 34 |
| | | 800 | 238 | 140 | 12 | 26 | 23 |
| | Temper at 1100F (43 $R_c$) | 600 | 185 | 150 | 12 | 46 | 44 |
| | | 800 | 172 | 140 | 15 | 50 | 42 |

### Corrosion resistance

These are martensitic stainless steels and are not noted for their resistance to corrosive media. They lack the corrosion resistance of 18-8, but have oxidation and

scaling resistance entirely adequate for application at temperatures up to 1200F and over.

**Applications**

These steels are used in the aircraft industry for such parts as compressor blades and rotor disks where their combination of oxidation resistance and strength is particularly important. They have a relatively low thermal coefficient of expansion and are used in certain structural applications where an austenitic stainless steel is inadequate because of excessive expansion on heating.

**Acknowledgment**

The assistance received in the preparation of this manual from the personnel and publications of the following organizations is gratefully acknowledged:

Allegheny Ludlum Steel Corp.
Alloy Casting Institute
American Iron and Steel Institute
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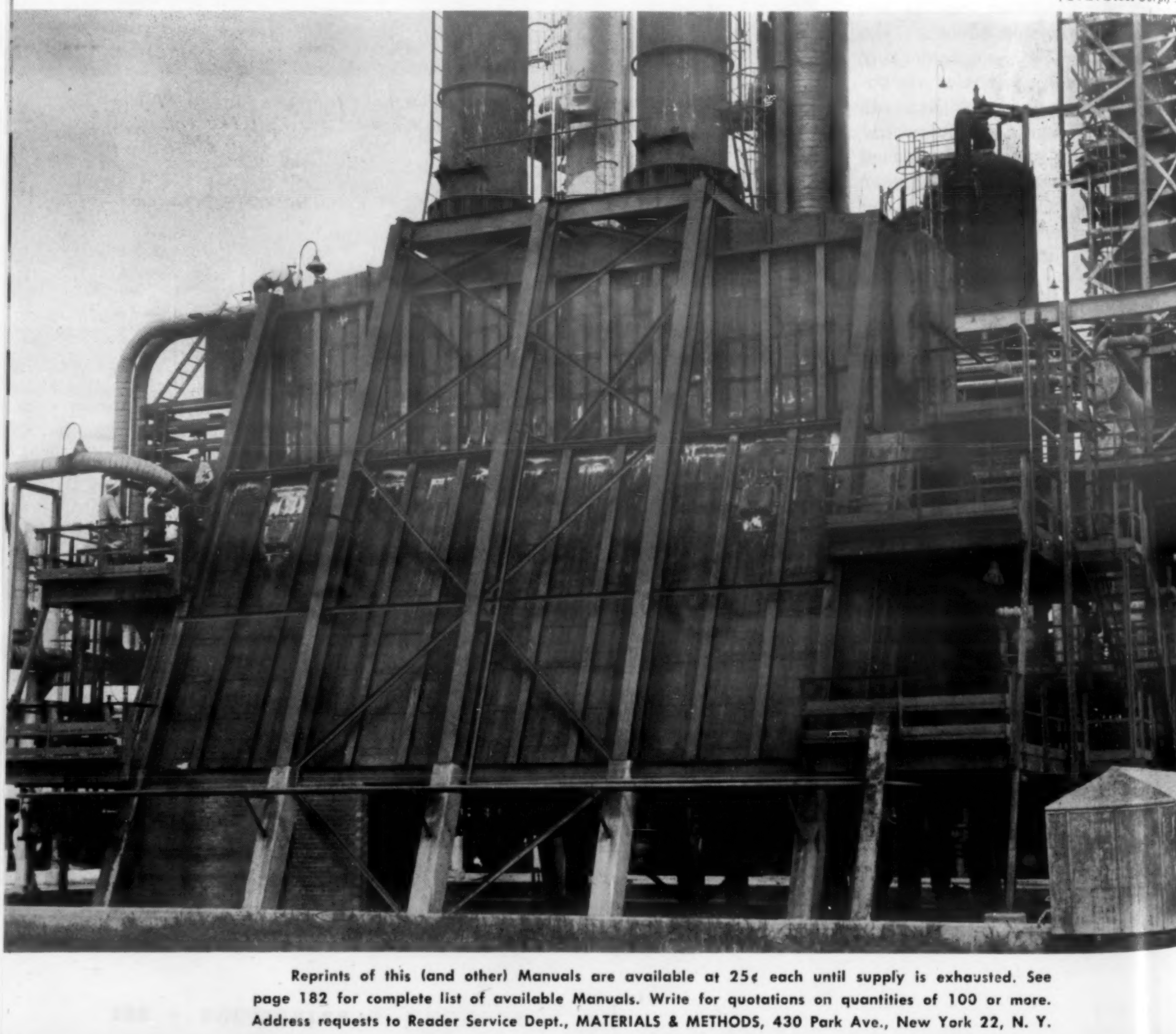
Electric Steel Foundry Co.
Electro Metallurgical Co.
Firth Vickers, Ltd.
Ford Motor Co.
Lebanon Steel Foundry
Standard Oil of Indiana
Timken Roller Bearing Co.
U. S. Steel Corp.
William Jessop and Sons, Ltd.

**STRESS-RUPTURE PROPERTIES OF FERRITIC STEELS AT 1100 F**

| Designation | Condition | Stress, 1000 psi, for Rupture in | |
|---|---|---|---|
| | | 100 hr | 1000 hr |
| Rex 448 | Oil quench from 2100F temper at 1200F | 51 | 41 |
| | Air cool from 1850F temper at 1200F | 45 | 35 |
| H46 | Air cool from 2100F temper at 1150F | 42 | 34 |
| 422 | Oil quench from 1900F temper at 1200F | — | 35 |
| 422M | Oil quench from 1900F temper at 1200F | — | 40 |

**_Straight chromium radiant tubes_** *in A-Frame furnace have an average life of 100,000 hr in this service.*
*(U. S. Steel Corp.)*



# MATERIALS ENGINEERING FILE FACTS

## Applications and Properties of Mechanical Felts

| Type ([b]) | Density, Lb/cu ft | Application | Nom Thick, in. | Mullen Bursting[c] Strength, psi | Porosity, % | Air Permeability, CFM/sq ft 0.5 in. $H_2O$ Gage | Retention Eff, %[a] |
|---|---|---|---|---|---|---|---|
| A all-wool | 10 | Multi-layer latex filter | 1/32 | 50 | 93 | 280 | 45 |
| B all-wool | 9 | Air conditioning and pollen filtering | 1/16 | 94 | 86 | 235 | 65 |
| C all-wool | 11 | Emulsion and dope | 1/16 | 125 | 86 | 130 | 76 |
| D all-wool | 13 | Industrial air conditioning | 1/16 | 130 | 86 | 105 | 88 |
| E all-wool | 14 | Air compressors; compressed air | 3/64 | 110 | 83 | 70 | 92 |
| F cotton blend | 11 | Cellulose lacquer and organic solvents | 3/32 | 225 | 86 | 50 | 94 |
| G all-wool | 17 | Oil and fuel | 3/32 | 220 | 66 | 30 | 96 |
| H all-wool | 20 | Industrial respirators and masks | 1/16 | 145 | 79 | 28 | 98 |
| I all-wool | 22 | Biochemical air intake filters | 1/16 | 120 | 79 | 13 | 99 |
| J silk blend | 30 | Toxic dusts, fumes and mists | 1/16 | 235 | 62 | 2 | 100 |

([a]) *Retention of 0.7 micron mean diameter mineral dust at rated permeability.*
([b]) *Filter felts are made of special wool fiber blends chosen for their ability to make a felt of specific porosity, permeability and retention characteristics.*
([c]) *ASTM D461-53.*

### Sheet and Roll Felts

| Trade Term | SAE Spec. No. | Typical Applications[1] | Nominal Densities, lb/cu ft | Classification[2] |
|---|---|---|---|---|
| **Sheet Felt** | | | | |
| Rock Hard | — | Heavy duty grinding and polishing wheels, bumpers | 43 | 32-S-1, 32-S-2, 32-S-3, 32-S-4 |
| Hard | — | Polishing granite, marble, glass tumblers; marking pens | 35 | 26-S-1, 26-S-2, 26-S-3, 26-S-4 |
| Medium | — | Polishing lenses, mirror and plate glass and wood; also in cash carrier heads, bumpers, ink rollers, punched wicks | 27 | 20-S-1, 20-S-2, 20-S-3, 20-S-4 |
| Soft | — | Wicks, washers, plugs, transfer rolls, polishing blocks | 21 | 16-S-1, 16-S-2, 16-S-3, 16-S-4 |
| Extra Soft | — | Fine and soft metal polishing, absorbent pads, shock mountings and anti-vibration pads | 16 | 12-S-1, 12-S-2, 12-S-3, 12-S-4 |
| **Roll Felt** | | | | |
| Back Check | F-1, F-2, F-3 | Washers, bushings, wicks, ink rolls and pads, door bumpers, polishing blocks, wheels and pads, anti-vibration and dampening pads, window channels, oil and grease shields | 21 | 16-R-1, 16-R-2, 16-R-3 |
| Extra Firm Pads | F-5, F-6, F-7 | Dust shields, wipers, grease retaining washers, wicks, anti-vibration mountings | 16 | 12-R-1, 12-R-2, 12-R-3 |
| Firm Pads | F-10, F-11, F-12, F-13, F-15 | Grease and oil retainers, dust shields, sound deadening, chassis strips, pedal pads, dash liners | 11.3 | 9-R-1, 9-R-2, 9-R-3, 9-R-4, 9-R-5 |
| Soft Pads | F-26 | Packing and padding | 9.6 | 8-R-16 |
| Ball Bearing | F-50, F-51 | Ball and roller bearing oil retainers and small dust-excluding washers, gaskets, liners and other thin cut parts | 21 | 16-RX-1, 16-RX-3 |
| Lining | F-55 | Anti-squeak strips, lining cemented to fiber board and metal panels | 16 | 12-RX-3 |

[1] *Typical applications listed are illustrative, rather than specific or limiting. Conditions governing the use of felts determine selection of the material.*

[2] *Felt classifications are based on the construction, i.e., fiber blends or "mixes," and density of the material. Several types, serving assorted uses, are customarily fabricated in each of the principal classes.*

*Standard nomenclature consists of a three-unit code in which the first number indicates the surface density, (weight equivalent of one square yard, one inch thick) a letter, ("S" for felts fabricated in sheets 36 x 36 inches. "R" felts fabricated in rolls 40 yards long and 60 inches or 72 inches wide) and a second number indicating the type of fiber composition, which has a basis in the U.S. Standard wool grade classification.*

◄ For more information, Circle No. 482


*The "Blue Ribbon", resistor with a higher wattage rating per unit space requirement. Made by Hardwick, Hindle, Inc., Newark, N. J.*

# because of DRIVER-HARRIS 146 ALLOY

Here is a resistor really new and different . . . the compact Hardwick, Hindle "Blue Ribbon," which stands remarkably high overloads and excessive heat without crazing.

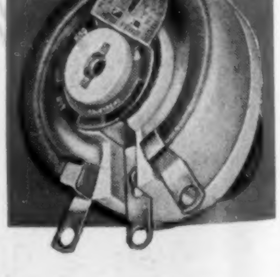
Special design features which make this possible are: an aluminum thru-bar extending through the center of the elliptical ceramic core, which insures a more even distribution of heat to prevent "hot-spots;" and a thermo-shock-proof enamel coating which eliminates crazing.

Heretofore, crazing, which occurred mostly at *terminal* areas, shortened resistor life and limited the safety factor. To prevent this, an alloy with three hard-to-find qualities was needed: (1) It had to have a coefficient of expansion to match all integral parts; (2) it had to be free of gas; (3) it had to form a perfect bond with the enamel.

A large order, indeed. But Driver-Harris filled it by developing #146, a glass-to-metal sealing Alloy. This alloy now makes it possible to operate resistors and rheostats at hitherto dangerous overloads, with no risk of breakdowns in the enamel coatings.

146 Alloy is one of 4 Driver-Harris Alloys which cover most glass-to-metal sealing needs—available as rod, wire, strip, sheet foil, and in special shapes. Today the makers of the "Blue Ribbon" use 146 Alloy for the terminals in all of their resistors and rheostats as well. They also use Nichrome*, Advance*, and other gas-free resistance alloys made by Driver-Harris in winding the cores.

What you can learn from this is clear. If you also need a special purpose alloy, send us your specifications. Our engineers with 48 years of experience are at your service.



*One of a new line of "H" Series high wattage rheostats made by Hardwick, Hindle, using Driver-Harris Alloys.*

*T. M. Reg. U. S. Pat. Off.

Nichrome and Nichrome V are made only by

SPECIAL PURPOSE ALLOYS SINCE 1899 · D/H · TRADE MARK REG. U. S. PAT. OFF.

**Driver-Harris Company** HARRISON, NEW JERSEY

**BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco**

In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

**For more information, turn to Reader Service Card, Circle No. 328**

(Continued from p. 155)

**Condensed Average Test Records Compared With SAE Specifications for Roll Felt**

| SAE Spec. | Thickness in. | | Density lb/cu ft | Breaking Strength, psi | | | Splitting Resistance lb/ 2 in. width | | | Wool Content, % | | Solubles,[1] % | | | | | | Ash, % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | $CCl_4$ | | $H_2O$ | | Combined | | | |
| No. | Nom | Test Data | Test Data | SAE Min | Test Data | | SAE Min | Test Data | | SAE Min | Test Data | SAE Max | Test Data | SAE Max | Test Data | SAE Max | Test Data | SAE Max | Test Data |
| | | | | | L | W | | L | W | | | | | | | | | | |
| F-1 | .250 | .251 | 22.1 | 500 | 810 | 835 | 33 | 38 | 36 | 95 | 98 | 2.5 | 0.9 | 2.5 | 0.9 | 3.0 | 1.9 | 1.5 | 0.5 |
| | .500 | .516 | 19.3 | 500 | 850 | 720 | 33 | 42 | 44 | 95 | 98 | 2.5 | 0.8 | 2.5 | 1.5 | 3.0 | 2.3 | 1.5 | 0.6 |
| F-3 | .250 | .260 | 20.0 | 400 | 450 | 490 | 22 | 26 | 24 | 90 | 94 | 2.5 | 2.1 | 3.0 | 1.7 | 4.5 | 3.8 | 2.5 | 1.2 |
| | .500 | .523 | 20.1 | 400 | 475 | 550 | 22 | 32 | 29 | 90 | 95 | 2.5 | 2.1 | 3.0 | 1.2 | 4.5 | 3.3 | 2.5 | 1.0 |
| F-5 | .250 | .271 | 15.0 | 400 | 640 | 450 | 18 | 18 | 18 | 95 | 98 | 2.5 | 1.1 | 2.5 | 1.4 | 3.0 | 2.4 | 2.0 | 0.7 |
| | .500 | .521 | 15.4 | 400 | 640 | 565 | 18 | 21 | 19 | 95 | 97 | 2.5 | 0.6 | 2.5 | 1.6 | 3.0 | 2.2 | 2.0 | 0.6 |
| F-10 | .250 | .267 | 11.4 | 225 | 380 | 280 | 8 | 9 | 8 | 95 | 98 | 2.5 | 0.6 | 2.5 | 1.1 | 3.0 | 1.8 | 2.5 | 0.6 |
| | .500 | .544 | 11.0 | 225 | 400 | 325 | 8 | 8 | 8 | 95 | 98 | 2.5 | 0.5 | 2.5 | 1.3 | 3.0 | 1.8 | 2.5 | 1.0 |
| F-11 | .250 | .253 | 11.8 | 200 | 310 | 230 | 6 | 8 | 9 | 92 | 94 | 3.0 | 3.1 | 2.5 | 1.6 | 4.5 | 4.7 | 3.0 | 1.0 |
| | .500 | .479 | 12.2 | 200 | 300 | 240 | 6 | 9 | 9 | 92 | 94 | 3.0 | 3.7 | 2.5 | 1.2 | 4.5 | 4.9 | 3.0 | 0.9 |
| F-15 | .250 | .280 | 10.7 | 75 | 170 | 130 | 2 | 6 | 5 | 55 | 86 | 4.0 | 1.6 | 5.0 | 2.8 | 9.0 | 4.4 | 4.0 | 1.8 |
| | .500 | .528 | 11.2 | 75 | 180 | 130 | 2 | 4 | 4 | 55 | 88 | 4.0 | 1.7 | 5.0 | 2.8 | 9.0 | 4.5 | 4.0 | 1.9 |

[1] *ASTM D461-53.*

| SAE Spec No. | Abrasion Wear Felt to Felt 10,000 Rubs/8 in. Stroke | | | Coefficient of Static Friction | | | | Oil Absorption and Capillary Flow SAE No. 20 Oil at 70 F | | | | | | | | Thermal[1] Conductivity K-Factor (1 in. Felt) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Decrease in thickness at stated loads in oz/sq in. | | | Felt Against | | | | 24 Hr Absorption | Wicking Rate In./Min Lapsed Time | | | | | | | |
| | 3.8 | 7.0 | 10.2 | Wood | Glass | Metal | Oiled Metal | % Wgt Increase | 5 | 10 | 15 | 30 | 60 | 90 | 120 | Btu/hr/sq ft/in./F |
| F-1 | 1.0 | 2.3 | 2.1 | .37 | .26 | .22 | .18 | 185 | 0.5 | 0.7 | 0.8 | 1.1 | 1.6 | 2.0 | 2.2 | 0.36 |
| F-3 | 2.1 | 2.1 | 3.0 | .37 | .26 | .22 | .18 | 265 | 0.5 | 0.7 | 1.0 | 1.3 | 1.7 | 1.8 | 2.1 | 0.36 |
| F-5 | 3.0 | 3.0 | 6.0 | .37 | .26 | .22 | .18 | 320 | 0.6 | 0.8 | 1.0 | 1.3 | 1.7 | 1.9 | 2.0 | 0.30 |
| F-15 | 4.1 | 7.6 | 18.5 | — | — | — | — | 570 | 0.6 | 0.9 | 1.1 | 1.4 | 1.6 | 1.8 | 1.9 | 0.24 |

[1] *Thermal and acoustical felts blended with Kapok fiber have tested values of 0.21 K factor and 0.80 sound-absorption coefficient at 512 cps for 1-in. thicknesses of 3.2 lb per sq yd weight.*

**Average Percent Compression Set and Deformation of Standard SAE Felts at Stated Loads**

| SAE Spec No. | F-1 | | F-3 | | F-5 | | F-10 | | F-11 | | F-15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Density—lb/cu ft | 21 | | 21 | | 16 | | 11.3 | | 11.3 | | 11.3 | |
| Deformation—% | Load, psi | Comp Set, % | Load, psi | Comp Set, % | Load, psi | Comp Set, % | Load, psi | Comp Set, % | Load, psi | Comp Set, % | Load, psi | Comp Set, % |
| 10 | 21 | 1 | 13 | 1 | 6 | 1 | 4 | 1 | 4 | 1 | 3 | 1 |
| 30 | 110 | 4 | 93 | 6 | 41 | 4 | 9 | 3 | 15 | 4 | 10 | 4 |
| 50 | 480 | 11 | 420 | 12 | 215 | 10 | 58 | 9 | 72 | 9 | 64 | 10 |
| 80 | 27,900 | 53 | 21,200 | 55 | 7750 | 53 | 2380 | 40 | 2620 | 42 | 3420 | 42 |

*Courtesy The Felt Association*

# NEW MATERIALS PREVIEWS

*More versatile malleable iron*
*High temperature block insulation*
*Zinc-copper electroplate*

*Boron-bismuth addition makes . . .*

## Thick Sections More Feasible in New Pearlitic Malleable Iron

■ A pearlitic malleable iron produced by a new process can be cast in section thicknesses as great as 2½ to 3 in. with consistently high mechanical and physical properties, yet requires no more than a 20 to 22 hr anneal during the malleabilizing cycle.

Key to the process is the use of bismuth and boron to control primary graphite formation. Developed by the *Central Foundry Div., General Motors Corp.*, Saginaw, Mich., the material, called "Bisbo", is the latest addition to GM's pearlitic malleable irons known commercially as ArMa Steels. Using ArMa Steel, and a 20-22 hr anneal, castings with optimum consistent mechanical properties were limited to about 1½ in. in section thickness.

**Mechanical properties**

Depending on tempering treatments, tensile strength of Bisbo iron ranges from 70,000 to 80,000 psi, yield strength from 48,000 to 60,000 psi, elongation in 2 in. from 4.0 to 3.0%, and Brinell hardness from 241 to 163. A special heat treatment for high strength parts, involving reheating to 1600 F for 20 min. then oil quenching and drawing at 1175 for 1½ hr, produces tensile strength of 100,000 psi, yield strength of 80,000 psi, elongation in 2 in. of 2.0%, and Brinell hardness of 241 to 269.

Castings show good machinability after all heat treatments. Since some carbides are retained in solution, local hardening can be accomplished with a single pass in flame or induction hardening equipment. A minimum hardness of Rc 50 can be obtained without difficulty.

The material has good damping capacity, fatigue strength and wear resistance. It has a modulus of elasticity of 26 to 28 million psi, thermal coefficient of expansion of 6.6 x $10^6$, a density of 0.266 lb per cu in., and a specific gravity of 7.37.

**Current uses**

Crankshafts in one complete line of GM cars are now being cast in Bisbo iron, replacing

---

### *Process differences*

**The old . . .**

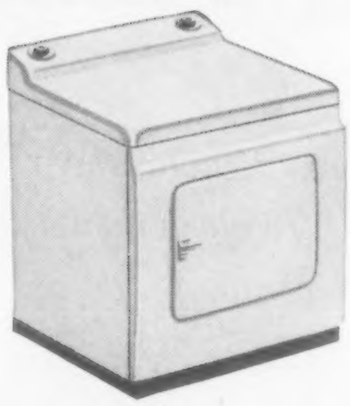
ArMa Steel pearlitic malleable irons are all produced in the same general way: 1) casting white iron, 2) malleabilizing in a controlled atmosphere furnace, 3) arresting the malleabilizing anneal with a quench, and 4) drawing to required hardness.

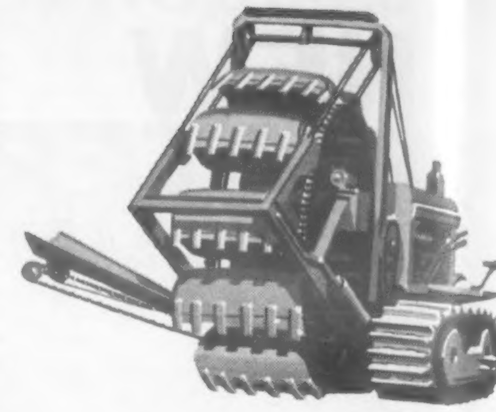
Variations can be introduced into the process to obtain special properties in the finished material. The factor determining the hardness and strength of the iron is the percentage of combined carbon remaining in the matrix, as determined by heat treatment.

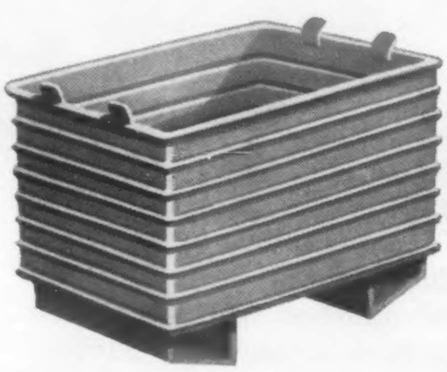
**The new . . .**

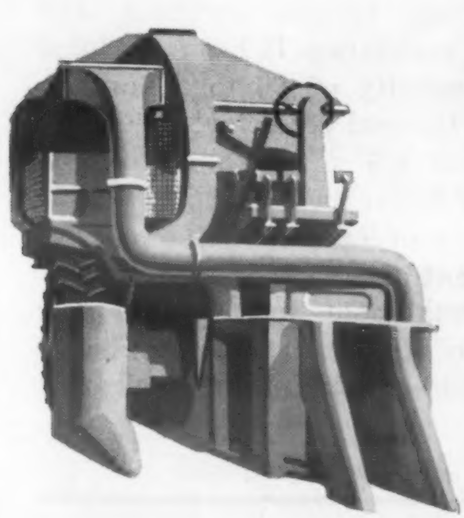
Bisbo pearlitic malleable iron consists of steel, remelt, and ferrosilicon which produces the white iron. Between 0.0025 and 0.0030% boron is added to assist in breaking down carbides during the malleabilizing anneal. In order to stabilize the carbides during initial freezing of the metal, about 0.005 to 0.007% bismuth is added as a ladle inoculant. Though use of boron is common, the use of a combination of boron and bismuth to control graphitization is new.

The malleabilizing cycle requires 20 to 22 hr for the anneal, and just under 7 hr for the draw. Annealing furnaces are held at 1750 F maximum and, near the end of the cycle, temperatures are reduced to about 1650 F. Castings are then quenched in circulating air. Hardness after quenching is on the order of 270 to 300 Brinell.









# MAKE IT WEIGH LESS

# N·A·X

HIGH-TENSILE STEEL

# MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel —it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

**N-A-X Alloy Division**

**GREAT LAKES STEEL CORPORATION**

**Ecorse, Detroit 29, Mich. • A Unit of**

**NATIONAL STEEL CORPORATION**

**For more information, turn to Reader Service Card, Circle No. 398**

forged steel crankshafts. Greater damping capacity in the cast metal is said to make for quieter operation, and the excellent machinability of malleable iron improves tool life during turning.

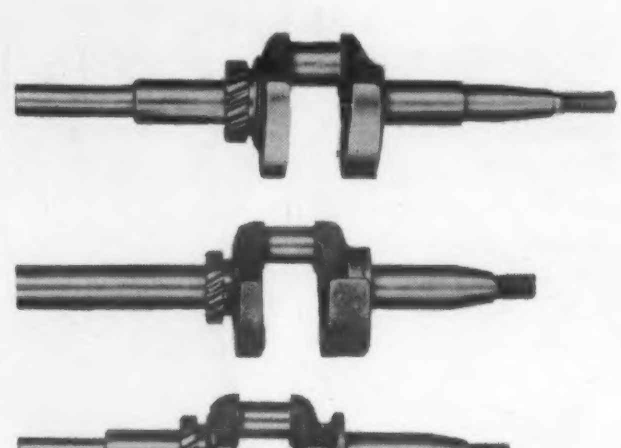
Most GM cars being built today are using rocker arms cast in this pearlitic malleable iron, replacing forged parts of SAE 1020 or 1035 steel. Use of Bisbo iron permits simple localized hardening of the pads on the rocker arm.

Other uses for Bisbo iron would be for parts where the characteristics of malleable iron would be advantageous, yet heavy section thicknesses and the economy of short annealing cycles are mandatory.

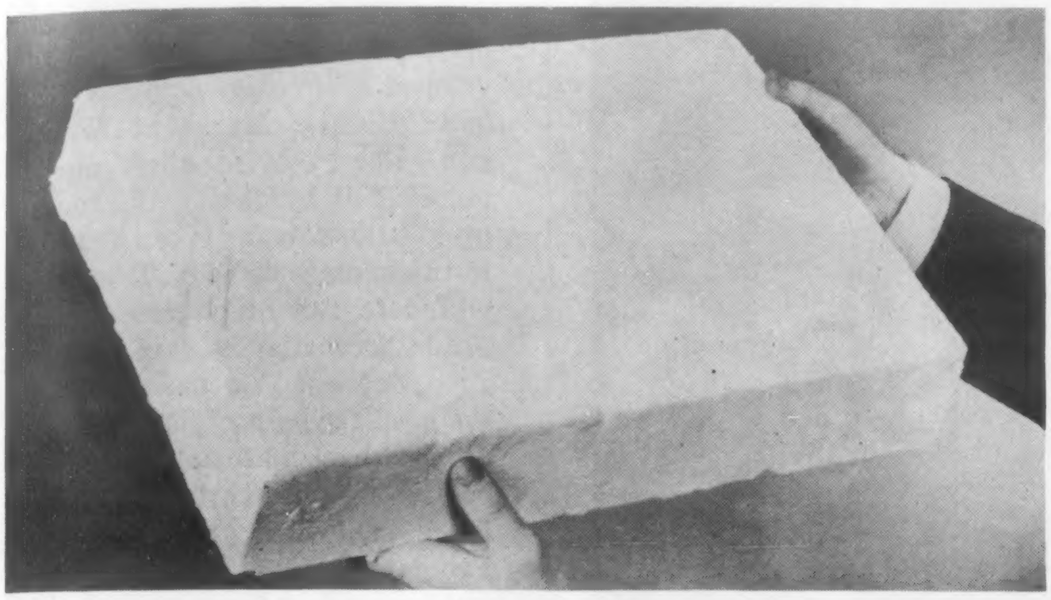
*(More Previews on p. 163)*

**Case history—Rocker arms** Bisbo iron has replaced SAE 1020 and 1035 steels in many automotive rocker arms. To obtain the necessary hardness and wear resistance on the pads in SAE 1020 forged rocker arms, pads had to be carburized and quenched. With SAE 1035 rocker arms, pads would harden when oil quenched, but bronze bushings had to be used in the bearing portion adjacent to the rocker arm shaft. Casting in Bisbo iron eliminated bronze bushings and made it possible to harden pad areas locally by induction heating or by immersion of these areas in lead or salt baths, thereby retaining required ductility in remainder of rocker arm. In addition to direct savings in original cost of the piece and a saving in heat treat costs, savings in machining have been reported.

**Case history—Universal joint yokes** Universal joint yokes for automobile propeller shafts are highly stressed parts and were made of SAE 1145 or 1151 forgings. Shaft of yoke is turned on outside surface, and splines broached on inside. Because of service stresses, a high yield strength is one requirement. Several manufacturers switched to pearlitic malleable iron to obtain improvements in machinability and found that strength characteristics were equal to or better than those of steel yokes. Number of pieces that could be broached before tool grinding was necessary was two to three times that of steel yokes.



**Case history—Small crankshafts** Crankshafts for small horsepower gas engines have been machined from steel forgings. Requirements include good strength, good damping capacity, good response to heat treating and good machinability (for machining journals, chasing threads and cutting gear teeth). By using investment casting techniques a weight saving was achieved in Bisbo pearlitic malleable iron castings. Machinability is superior to that of steel forgings and hardenability is satisfactory. Overall costs are reported to have been reduced substantially.



**Resistant to 2300 F** *temperatures, the new block insulation has a density of 20 lb per cu ft.*

*Higher strength and density in...*

## Inorganic Block Insulation

■ Higher compressive strength and density are claimed for a high temperature-resistant ceramic fiber block insulation developed by *The Carborundum Co.*, Niagara Falls, N. Y. Designed for service temperatures up to 2300 F, the F-20 Fiberfrax block (*For information on Fiberfrax fiber of which the block is made see* M&M, *Sept '52*) is chemically inert and withstands flame impingement.

The F-20 block has an approximate density of 20 lb per cu ft, compared with 13 lb per cu ft for the older F-13 block. Greater density results in greater compressive strength. With F-20, a pressure of 12 psi is required to compress a standard specimen 0.009 in. per in. of thickness, compared with 6 psi for the F-13. Under ASTM test C-165, block deformation from a 4.47 psi load is 1% for F-20. An increase to 13.78 psi causes a deformation of 10%. Modulus of rupture is 48 psi, though treatment with an inorganic compound can increase the modulus to 69 psi.

Thermal conductivity of F-20 at a mean temperature of 1000 F is 1.27 Btu/hr/sq ft/F/in. At a mean temperature of 2000 F thermal conductivity is 2.24. For the older F-13, thermal conductivity at a mean temperature of 1000 F is 0.88, and at 2000 F it is 1.87.

The new block insulation has low shrinkage after exposure to elevated temperatures. Linear shrinkage after a 12-hr soak at 1500 F is 0.21%, and after 24 hr at 2300 F shrinkage is 3%.

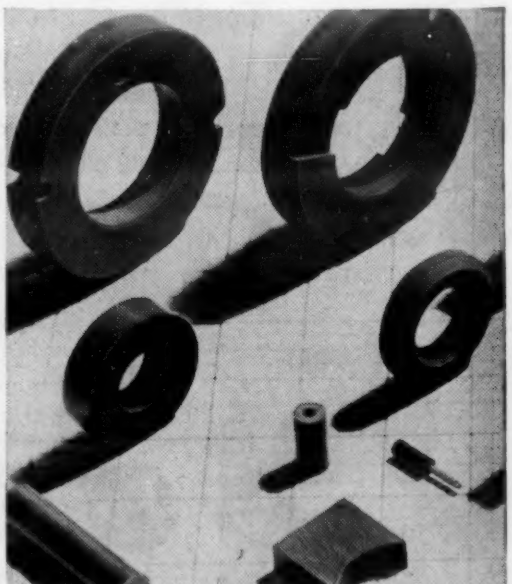
The blocks are available in sizes of 12x12, 18x12, 18x6, 36x6 and 36x12 in., in thicknesses ranging from 1½ to 4 in. in ½-in. increments.

## Low Cost Ceramic for Permanent Magnets

A low cost ceramic permanent magnet material, consisting of barium and iron oxides, has been developed by *Stackpole Carbon Co., Electronic Components Div.*, St. Marys, Pa. The material is said to combine adequate energy product with high coercive force, low residual induction, virtually 100% electrical resistivity, and resistance to demagnetization. These features, plus the low cost and non-critical nature of the ceramic material, make such magnets well suited for ordinary permanent magnet uses, and for those of a more exacting nature.

Called Ceramagnet permanent magnet, the material is said to retain its energy even when used without keepers or under closed-circuit conditions. Electrical resistivity is $6 \times 10^{10}$ ohm/cu cm. Temperature characteristics of the material are linear, including retrace, up to 750 F. It has an energy of $0.915 \times 10^{6}$ gauss-oersteds at 600 gauss working point. Classed among the hard magnetic materials, it can be machined by wet grinding and may be machined after magnetizing. Units are available in any size and shape.

*(More New Materials on p. 164)*

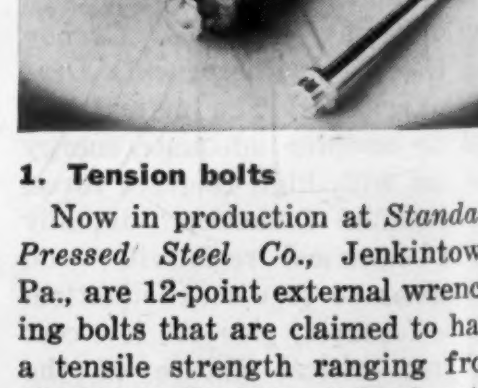


# OTHER NEW MATERIALS, PRODUCTS

## Zinc-Copper Alloy Electroplated Coating

A new zinc-copper alloy electroplate called Probrite has been developed by *Promat Division, Poor and Co.,* 851 S. Market St., Waukegan, Ill. Probrite alloy can be plated full bright in thicknesses up to 0.0003 in., or it can be plated in thicknesses up to 0.001 in., then buffed to full brightness. Buffing grade Probrite is said to have good flow-out. Its use eliminates the need for using "plating grade" finished base materials. Bright deposits can be chromium plated for added color and sealed in Promat Proseal S-30-A for protection against formation of white corrosion products. Though widest use for the plate is in indoor applications, the plate meets requirements for many outdoor applications. One of its principal advantages lies in the availability of the metals that make up the deposit.

## Three Mechanical Fasteners



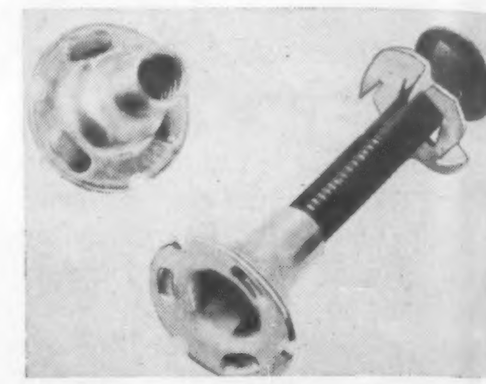
**1. Tension bolts**

Now in production at *Standard Pressed Steel Co.,* Jenkintown, Pa., are 12-point external wrenching bolts that are claimed to have a tensile strength ranging from 180,000 to 200,000 psi. Designated EWB-18, these aircraft-type tension bolts are said to have exceptional resistance to dynamic fatigue or shock loading and to permit a reduction in size or num-

For more information, Circle No. 445 ➤

## OTHER NEW MATERIALS, PRODUCTS

ber of bolts needed for a given job. They are made from 4340 and 8740 alloy steels and are cadmium plated by the fluoborate method.



**2. Nuts and washers**

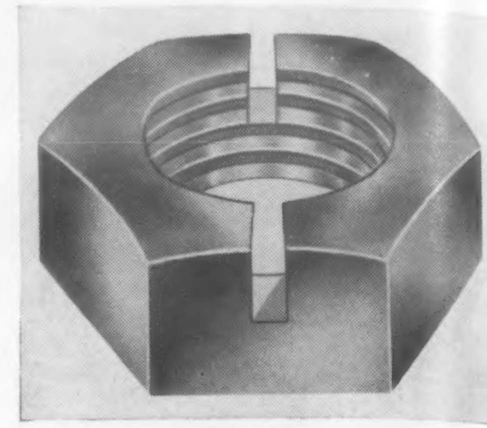
A combination nut-and-washer fastener for high speed industrial wood applications has been developed by *Frank L. Robinson Co.*, Latham Square Bldg., Oakland 12, Calif. Requiring only one drilling operation, Ace Kwik nuts need no counterboring which might weaken boards. Ace Torque washers have prongs deeply embedded in the wood to prevent turning of carriage bolts. These fasteners are easily installed by using an angle hand allen wrench, straight power-type allen wrench, or a power spanner wrench.

**3. Stake nuts**

Heavy duty fastening applications involving the mounting of metal parts and panels are said to be made more secure with a multiple-thread nut clip manufactured by *Prestole Corp.*, 1345 Miami St., Toledo 5, Ohio. A lower leg has a formed catch that holds the nut in position on the panel hole for ease of assembly, then acts as a lock washer. This stake nut fastener has many applications in the automobile field and is especially desirable for use where vibration, stress and strain are prevalent.

*(More New Materials on p. 168)*

## OTHER NEW MATERIALS, PRODUCTS



**4. Self-locking nuts**

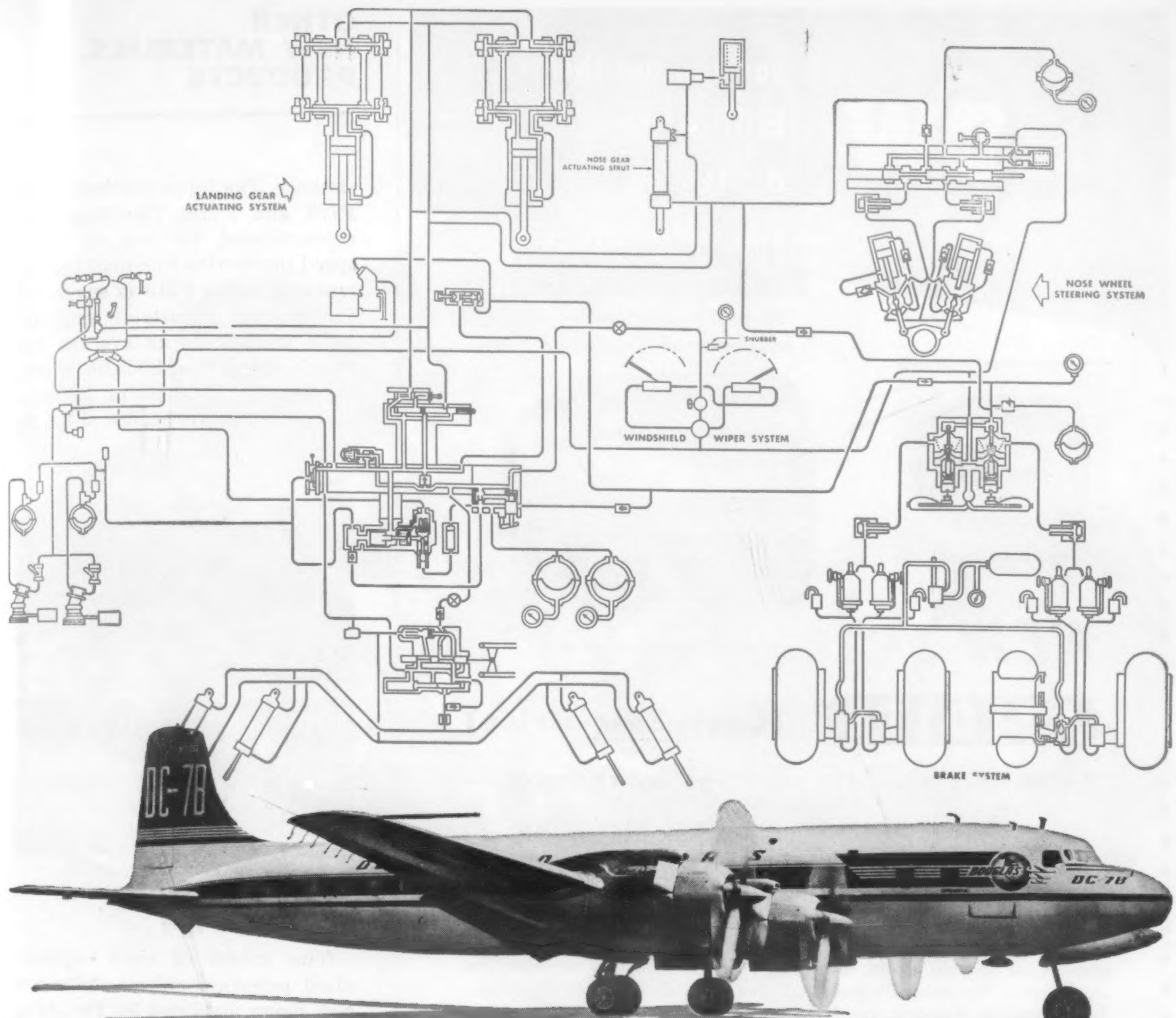
One-piece, free spinning, reusable self-locking nuts are made by *Jacobson Nut Mfg. Corp.*, Box 177, Kenilworth, N.J. The upper portion of the nut is slotted and the bottom face is undercut so that when the nut is tightened, the threaded upper segments move inward causing the nut to produce a vibration-proof lock on the threads of the screw. These self-locking nuts, made of steel, brass, aluminum and stainless steel, are available in all machine screw sizes.

### Low-Temperature Enamels for Thin Metals

Low-temperature porcelain enamel intended primarily for use on products manufactured of light gage metals are being produced by *Pemco Corp.*, 5601 Eastern Ave., Baltimore 24. Fused at temperatures of 1250 to 1300 F, the enamels are said to be well suited for use in air conditioning units, refrigerator exteriors, clothes dryers, kitchen cabinets and other items manufactured of light gage metal.

### Kraft-Backed Masking Tape

Two all-purpose masking tapes consisting of 30-lb kraft paper backings and transparent, rubber-based, pressure-sensitive adhesives have been marketed by *Permacel Tape Corp.*, New Brunswick, N.J. The adhesives are said to have good heat and stain re-




# Enjay Butyl rubber—vital artery in newest airliners

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Versatile Enjay Butyl rubber may well have a place in *your* operation. It will pay you to investigate the many technical advantages it has over other types of rubber. Its price and ready availability are advantages, too. For full information, and for technical assistance in the uses of Enjay Butyl, contact the Enjay Company today.

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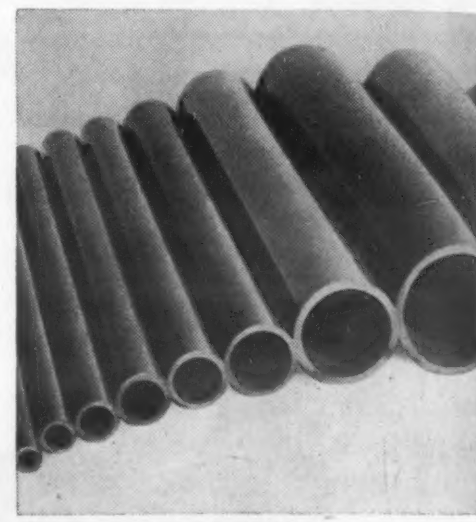
sistance. The tapes are designated P708 and P718. The former is recommended for use on high-speed production line masking operations, while P718 is suggested for general industrial masking. Both tapes have an average dry tensile strength of 20 lb/in. width, an average thickness of 6.6 mils, and edge tear resistance of 3.5 lb.

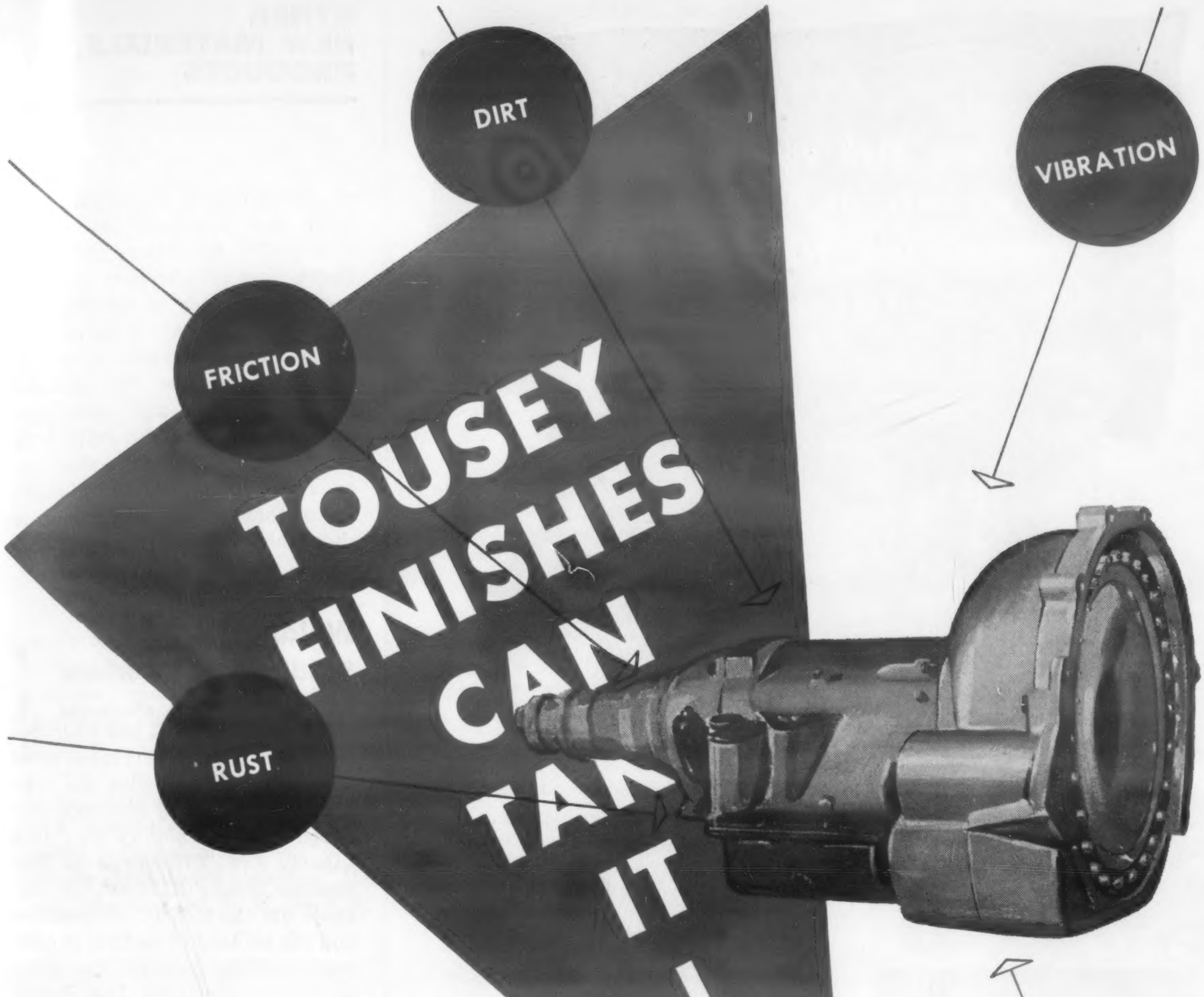


## New Source For PVC Pipe

Two grades of rigid unplasticized polyvinyl chloride pipe are now being marketed by *The Alloy Tube Div., The Carpenter Steel Co.,* Union, N.J. Carpenter PVC No. 1 is a normal impact grade with high chemical resistance. Carpenter PVC No. 2 is a high impact grade with slightly less chemical resistance but greater strength. Threaded and socket types of fittings are available. PVC pipe is available in Schedules 40 to 80 in nominal sizes ranging from ½ to 4 in. All pipe is furnished in standard 10- and 20-ft lengths with plain ends.

## Teflon-Coated Glass Yarn

Glass yarn in which the individual glass fibers have been coated with Teflon prior to braiding has been marketed by *L.O.F. Glass Fibers Co.,* 1810 Madison Ave., Toledo 1, Ohio. In previous types


DIRT
VIBRATION
FRICTION
TOUSEY FINISHES CAN TAKE IT!
RUST


HOT OIL
TOUSEY PRODUCTS
CASTING SEALER

## OTHER NEW MATERIALS, PRODUCTS

of Teflon-coated glass yarn, the yarn was braided, then coated with Teflon. By coating individual fibers, over-all abrasion and corrosion resistance of the yarn are improved. The yarn is being used in the aircraft industry to protect cables that must be installed through small and sometimes rough holes. It is also being used in Navy cable, coaxial cable, and as a sewing thread to fabricate items that must be resistant to chemicals.

## Welding, Brazing, Soldering Materials

**1. Low hydrogen electrode**

The versatility of low hydrogen electrodes and the increased speed of iron powder grades are combined in a welding electrode produced by *The McKay Co.*, 1005 Liberty Ave., Pittsburgh 22. Designated McKay E716-IP, the electrode fits the E-7016 classification and can be used in vertical or overhead welding. Rate of desposition is said to be about 35% higher than that of conventional low hydrogen electrodes. Ease of operation is said to reduce welder fatigue, thus increasing efficiency.

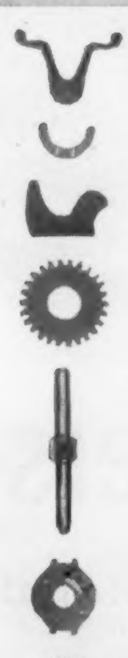
The electrodes may be used with reverse polarity, d.c. or a.c., at amperage levels higher than those normally associated with low hydrogen electrodes. Weld deposits have tensile strengths of about 81,000 psi, yield strengths of about 69,000 psi, and elongation in 2 in. of about 30% in the as-welded condition.

**2. All-position electrode**

An all-position E-6013 electrode, Fleetweld 37, designed particularly for ease of operation, has been marketed by *The Lincoln Electric Co.*, 22801 St. Clair Ave., Cleveland 17. For use with either a.c. or d.c., the electrode is said to be valuable where burn-through, sticking and poor fit-up are problems. It is also said to be useful with low open circuit voltage welding machines, such as are general-

**For more information, Circle No. 532 ➤**





## OTHER NEW MATERIALS, PRODUCTS

ly found in small shops. Drag techniques can be used.

**3. Mild steel electrode**

A general purpose high speed electrode for mild steel welding has been developed by *All-State Welding Alloys Co.*, 249-55 Ferris Ave., White Plains, N.Y. Low amperage (40-225) deposits from the electrode are said to have tensile strengths of 65,000-75,000 psi, yield strengths of 58,000-63,000 psi, and elongation in 2 in. of 26-34%. Designated Steelarc, the electrode can be used with a.c. or d.c. welders. It is recommended for welding structures such as boilers, tanks, pressure piping and railroad cars.

**4. Thoriated tungsten rod**

A 2% thoriated tungsten electrode for tungsten inert gas welding has been developed by the *Tungsten and Chemical Div., Sylvania Electric Products, Inc.*, 1740 Broadway, New York 19. In comparison to 1% thoriated electrodes, the new rods are said to provide easier arc starting, more stable arc, higher current capacity, longer life, and increased resistance to weld pool contamination.

**5. Ni-Cr-B-W hard-facing**

Available either in rod or powder form, a nickel-chromium-boron-tungsten hard-facing material has been developed by *Wall Colmonoy Corp.*, 19345 John R St., Detroit 3. Called Colmonoy No. 70, the material is said to protect parts exposed to vibration or heat against wear and corrosion. The alloy has a high tungsten content that hardens the matrix. Originally developed to overcome fretting corrosion at temperatures of over 1000 F on jet engine shafts, the material is also recommended for use in engine valves, chemical valves, acid pump parts, coal washers and cement screws. As a powder it can be used for spray-welding; in rod form it can be applied with a torch.

**6. Automatic build-up**

An automatic build-up wire, designed for use with the submerged arc process, has been marketed by *Air Reduction Sales Co., Div. of*

For more information, turn to Reader Service Card, Circle No. 394

## OTHER NEW MATERIALS, PRODUCTS

*Air Reduction Co., Inc.*, 60 E. 42nd St., New York 17. It is designed for use prior to final hard-facing. Deposits are said to be sound with ample ductility and to form good bonds with surface hard-facing materials. Deposits can be applied to all ordinary AISI and SAE steels and can be heat treated. With subsequent hard-facing, the material is designed for applications such as tractor rollers and idlers, earth moving shovel parts, and cable drums. As a build-up with no final hard-facing, it is recommended for use in restoring tractor track rails and links, large shafts, pulley sheaves, and mine car and crane wheels.

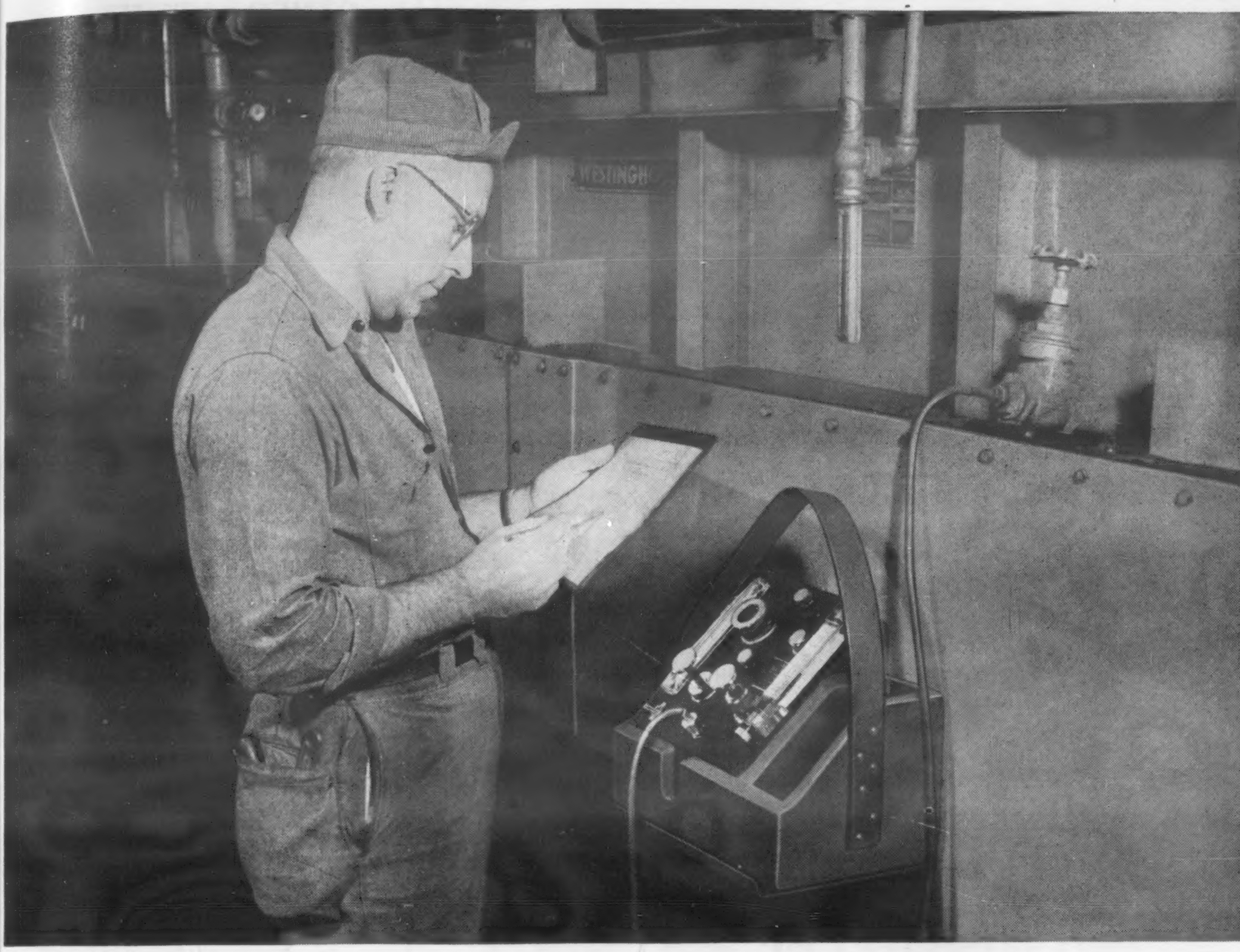
**7. Brass brazing rod**

A non-fuming, high strength nickel-brass rod, intended for joining or overlay with the oxy-acetylene process, has been developed by *Ampco Metal, Inc.*, 1745 S. 38th St., Milwaukee 46. Called Ampco-Braz No. 1, the rod provides deposits that will bond to a variety of copper, nickel and iron-base metals and alloys, producing silver-colored deposits. It is recommended for fabricating tubular steel furniture, instruments, bicycles and similar products where strong, attractive joints are required without warpage or distortion. Due to its high nickel content, it is also recommended for depositing tough overlays to combat wear and corrosion. Deposits are said to have good resistance to many acids, mild alkalies and salt water.

**8. Solder-flux paste**

An all-purpose solder-flux paste, designed for use on most metals except aluminum and magnesium, has been marketed by *Anchor Metal Co., Inc.*, 244 Boerum St., Brooklyn 6. Packaged in a plastics squeeze bottle, the material consists of a tin-lead solder and a chemically active flux suspended in an agent that assures free flow of the mixture. The solder-flux paste is applied to areas to be joined, then heat is applied by iron, torch, or furnace to the metal which in turn heats the solder-flux mixture.

*(More New Materials on p. 178)*

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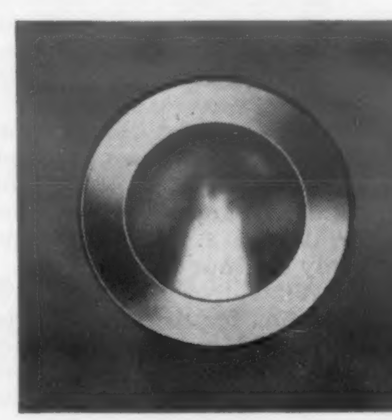

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## OTHER NEW MATERIALS, PRODUCTS

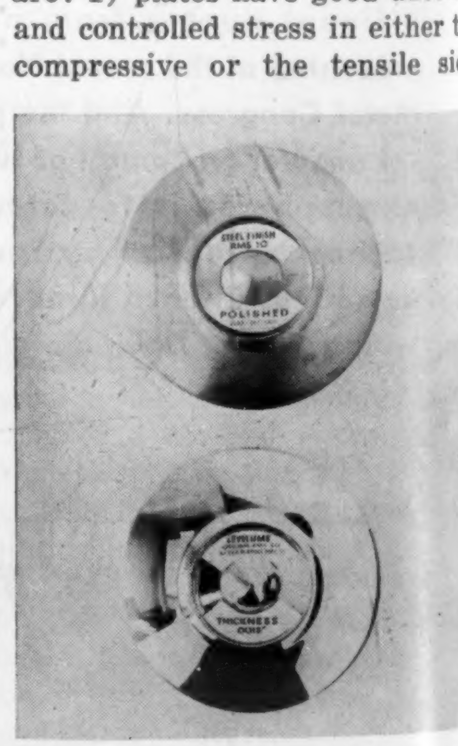
### Die Steel Takes Good Finish

A medium-carbon alloy die steel designed for use where cavities must have high surface finishes has been developed by *Vanadium-Alloys Steel Co.,* Latrobe, Pa. Called MC-Mold and Cavity Steel, the alloy can be uniformly deep hardened at hardness ranges of 300 to 350 Brinell throughout sections as large as 20x10 in. High surface hardnesses are obtainable by carburizing and oil quenching. A low heat treating temperature can be used so that little or no movement takes place during quenching. The alloy is available either annealed or heat treated to a hardness of 300 Brinell, at which hardness it is still readily machinable.

### High Speed Bright Nickel Plate

A bright nickel process that is said to combine full plate brightness, high leveling and speed of deposition has been developed by *Hanson-Van Winkle-Munning Co.,* Matawan, N.J. Called Levelume, the process is said to have deposition rates twice as great as the fastest processes now available.

Other advantages of the process are: 1) plates have good ductility and controlled stress in either the compressive or the tensile side,



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thereby minimizing cracking, crazing, lifting or brittleness; 2) good results are obtained at current densities up to 150 amps per sq ft; 3) high leveling qualities permit scratches and surface defects to be filled in, thus minimizing polishing and buffing usually necessary for high smoothness after plating; 4) deposits have a high degree of surface activity, permitting them to accept chromium and other deposits without additional treatment; and 5) recessed areas are uniformly bright without shading.

Key to the process are additive agents that permit use of an activated carbon pack in the plating solution filter. The activated carbon continuously removes harmful organic contaminants, making periodic batch purification unnecessary.

## Small Teflon Tubing for Insulation

So-called "Tensolon" Teflon spaghetti tubing has been marketed by *Tensolite Insulated Wire Co., Inc.*, 198 Main St., Tarrytown, N.Y. It is particularly designed for sleeving for electrical wiring applications where high temperatures are encountered. The tubing, made of du Pont's Teflon fluorocarbon plastic, has high dielectric strength and insulation resistance, a useful temperature range of −130 to 480 F, and resistance to all solvents and chemicals. Available in natural and nine solid colors, the tubing is produced in AWG sizes 26, 24, 22, 20, 18, 16, 14, 12 and 10. Other sizes are available on special request.

## Epoxy Hardener Has Low Toxicity

A new hardener for epoxy resins, Promoter D-40, is a mild, amine type which is considered to be relatively nontoxic due to its high boiling point and low order of reactivity. Developed by *Furane*

## OTHER NEW MATERIALS, PRODUCTS

*Plastics, Inc.*, 4516 Brazil St., Los Angeles, it is also said to produce a low exotherm, masses up to 40 lb of clear resin having been poured with no difficulty. Circuits and other devices requiring resin masses of 1 to 5 lb can be cured at temperatures between 140 and 160 F, producing exothermic heat of the order of 20 to 40 F over the existing oven temperature.

Curing at lower temperatures, which may take about 15 hr, produces gelation at a very slow rate. For greater fluidity, the resin-hardener mix can be warmed with no danger of premature gelation. The promoter has no offensive odor and does not crystallize, and preliminary skin tests have shown no evidence of skin irritation.

### New Coatings

**1. Abrasion resistant**

A coating consisting of a plastics material with dry film lubricants is said to be particularly well suited for use where abrasion and corrosion are encountered. Designated EverLube 1329, the coating can be sprayed, dipped or brushed, and can be cured by baking. Marketed by *EverLube Corp. of America*, 6940 Farmdale Ave., North Hollywood, Calif., the material can be used on such materials as magnesium, aluminum and steel. It is said to provide a high degree of abrasion resistance and to be unaffected by hydraulic fluids, gas turbine lubricating oil, and JP-4. Tests failed to show any deterioration of the coating after 500 hr in a weathering unit, and six months' outdoor exposure.

**2. Phosphate coating**

A phosphating material, known as Metacote, is said to provide steel, aluminum or zinc with a fine, tightly adherent coating which provides good paint adhesion and salt spray resistance. It is non-sludging and may be used in mild steel equipment. Marketed by *Metasurf Corp.*, 12830 Eaton Ave., Detroit 27, the material re-

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A tuning fork sounds the *standard pitch* to which musical instruments are compared. There's a recognized standard for high speed steels, too — Crucible REX®.

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## OTHER NEW MATERIALS, PRODUCTS

quires no special additive or secondary material to produce good results. Concentrations of the solution are controlled by means of a simple titration. A test kit is furnished with the material.

**3. Passivating polish**

A stainless steel polish that passivates as it cleans has been developed by *The Oscar Fisher Co.,* Peekskill, N.Y. The material is in powder form and is mixed with water for use. The solution removes any ferrous contamination and restores the original luster of stainless steel surfaces.

**4. Strippable plastics**

A strippable plastics coating, designed to protect smooth or polished metal surfaces during fabrication, handling and storage, has been marketed by *Guard Coatings Corp.,* 8-05 43rd Ave., Long Island City, N.Y. Called MetalGuard, the coating is sprayed on and dries to form a film with a tensile strength of more than 2500 psi and an elongation of 200%. It can be sprayed on stainless steel, glass, vitreous enamel, chromium, nickel, decorative laminates and plated surfaces. The cured coating can withstand such manufacturing operations as drawing, blanking, drilling, routing, rolling and riveting as well as shipping. The coating is also available in consistencies for brushing or dipping.

**5. Aluminum coating**

A chrome sealer that provides a film with a very low microhm resistance is said to protect aluminum from oxidation, thereby simplifying its use in electrical applications. Called Kenvert 40, the material is being produced by *Conversion Chemical Corp.,* Rockville, Conn. The coating can be applied continuously by dip or spray.

**6. Specialty coating**

A coating formulated to produce clean, sharp, opaque color contrast on recessed or embossed dials is being produced by *The Irvin, Jewell & Vinson Co.,* Dayton, Ohio. The material, called Anchor Dial Filler, produces a film that can be wiped off raised areas with a dry cloth during in-

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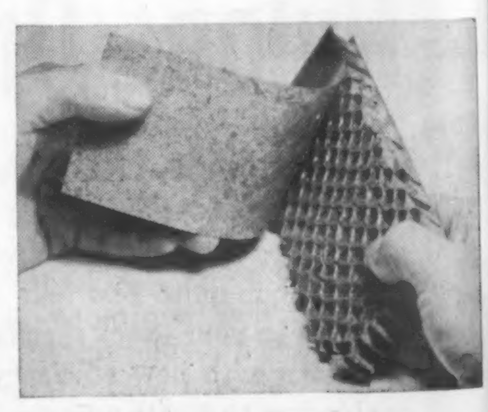
## OTHER NEW MATERIALS, PRODUCTS

itial drying time, leaving the coating that fills the pattern. Two formulations are available: a quick formula that dries in seconds, and one that can be dry-wiped for several minutes. The material can be applied to plastics, wood, metal or ceramic objects by brush, roller, squeegee or spray. It is available in flat or dull gloss and in shades to meet all color standards.

**7. Rubber coating**

A liquid rubber coating that is self-vulcanizing and requires no mixing has been marketed by *Rubba, Inc.*, 1015 E. 173rd St., New York 60. Called Rubbakote, the coating was developed primarily for protecting electroplating tanks from corrosion. The coating material is said to adhere to all types of metal and to dry within 30 min after application. It is not affected by acids or alkalies and can be applied by brush or spray.



### Adhesive Bonds Variety of Materials

An elastomeric-type adhesive for contact or hot bonding of a variety of porous and non-porous materials has been developed by the *Adhesives & Coatings Div., Minnesota Mining & Mfg. Co.*, 411 Piquette Ave., Detroit 2. Designated EC-1357, the adhesive is said to build up strength rapidly, to provide high adhesion to steel, and to have good resistance to plastic flow. It has a high softening point and can be sprayed. It can be used for bonding metal

frames to veneered plywood or to plastics.

The material is gray-green in color. It has a thin syrup consistency and weighs about 7 lb per gal.

According to 3-M, the adhesive provides bonds with twice the peel strength of other resin-type adhesives. Bonds will withstand temperatures up to 160 F. Tests of bonds between canvas and steel show that peel strengths after 96 hr aging at room temperatures are 15 times those obtained with 2 hr aging at room temperature.

Bonding surfaces are chemically cleaned and the adhesive applied by hand roller or by spray equipment. After infra-red drying, parts can be hand assembled and bonded while hot with one pass through a pressure roll. For low production bonding, air drying can be used. For contact bonding, a liberal and uniform coat of adhesive is applied to both surfaces. Wood and other porous materials usually require two coats. Both surfaces are then air dried for 15 to 45 min, and bonding pressure applied by hand roller working from center to edges.

## Contact Cement

High pressure plastic laminates can be cemented to wood without use of clamps or presses by an adhesive developed by *Adhesive Products Corp.*, 1660 Boone Ave., New York 60. Called Stix-Grip, it requires no heating and is said to be flexible and resistant to heat and cold. Following application



For more information, turn to Reader Service Card, Circle No. 339

## OTHER NEW MATERIALS, PRODUCTS

and a 30-min drying period, an immediate bond is said to be established when cemented surfaces are brought together. The adhesive can also be used to cement tile, marble, vinyl, thin wood veneer and metal trim to wood.

### Cold Punching Phenolic Laminate

A cold punching phenolic laminate developed particularly for automatic production of printed circuits has been marketed by *Laminated & Insulating Products Dept., General Electric Co.*, Dept. PRL-1, Coshocton, Ohio. Designated G-E Textolite cold punch 11570, the laminate is a high insulation-resistance XXXP paper-base laminate that permits close registration punching at normal room temperatures. Since no heat is required for punching, dimensional changes due to the combination of heat and punching stresses are eliminated. The laminate is translucent, has high flexural strength and heat resistance, and is said to provide the optimum in uniformity.

### Fluorocarbon Film Is Transparent

A colorless, transparent fluorocarbon film, made of polytrifluorochloroethylene (Kel-F or Fluorothene) has been marketed by *Shamban Engineering Co.*, 11617 W. Jefferson Blvd., Culver City, Calif. Called Califilm, the film is said to have outstanding electrical, physical and chemical properties. It is tough, non-porous and resistant to a range of chemicals and temperatures. High dielectric strength over a wide range of temperatures and humidity conditions is claimed.

Continuous re-use or aging does not embrittle the film, and it can be heat sealed using conventional techniques. The material can be used for many applications at tem-

# Rare Earth Chloride

## *available in large quantities at surprisingly low cost for a wide variety of industrial uses*

a report by LINDSAY

You have probably always thought that rare earths are really rare. Some of them are very rare and very, very costly.

Fortunately, however, rare earth chloride is readily available in commercial quantities (and we mean carloads) to serve a wide variety of industrial uses. It is one of the most economical sources of rare earths, some grades costing in quantity lots approximately 30¢ per pound.

Rare earth chloride is a natural mixture of hydrated rare earth chlorides produced from monazite ore. It contains chiefly the chlorides of cerium, lanthanum, neodymium, and praseodymium with smaller amounts of samarium, gadolinium, and less-common rare earth chlorides.

The rare earths are trivalent metals, and rare earth chloride is an excellent source, and an economical source, of these heavy metals. It is a water-soluble salt showing relatively little hydrolysis. Like most other rare earth salts, its basicity is generally like that of calcium salts.

• • • •

When you flick your cigarette lighter, you are using misch metal (the stuff of which lighter flints are made) and this is produced from rare earth chlorides. Misch metal itself is used as an additive in many grades of steel.

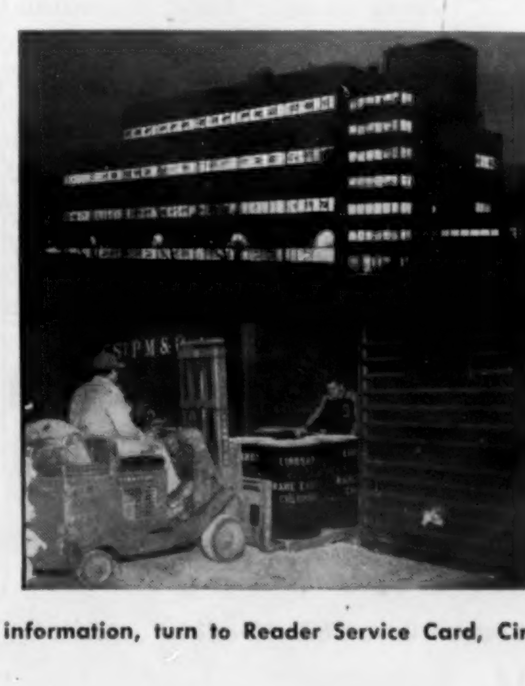
It's a versatile material, this rare earth chloride – it is used in paint and ink driers, as an anti-corrosive treatment for filter cloths, and in many other applications.

This unique material (there is nothing else quite like it) is challenging the imagination of research people in a wide variety of industries. Some see it as a possible replacement for other, higher cost materials. Others are exploring it with a view to improving production processes, enhancing product quality, and developing by-products.

Here are just a few of the many uses of rare earth chlorides. You are certain to discover others.

*Caries inhibitors in tooth paste and dentifrices. Chrome plating bath additive. Silk loading. Primary cell carbon anodes. Mordant for leather and textile dyeing. Additive to baths for applying hot dip coatings to aluminum. Stypulant for embalming. Ultra-violet light absorber. Catalyst. Trace elements in fertilizer. Textile waterproofing.*

You may have research projects or production processes in which rare earth chloride could be of help. To satisfy a researcher's insatiable curiosity, or to appraise its potentials in your operations, it will reward you to talk with us about rare earth chlorides. We'll be happy to send you technical data and a typical analysis.



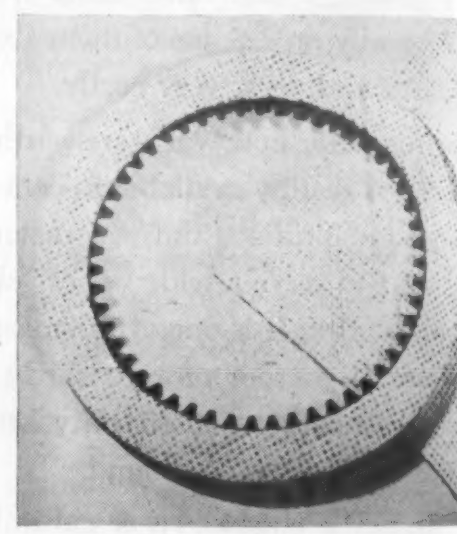
**Photos show latest addition to Lindsay monazite processing plant at West Chicago and a car being loaded with rare earth chloride for shipment to a Lindsay customer.**

LINDSAY CHEMICAL COMPANY

276 ANN STREET, WEST CHICAGO, ILL.

**For more information, turn to Reader Service Card, Circle No. 406**

peratures ranging from −120 to 390 F, and it can be sterilized in an autoclave. According to Shamban, the film can be used to provide positive insulation for resistors, solenoids, condensers, transformers, motors and generators. Non-wetting characteristics and resistance to fungus make the film useful in packaging, food handling, gasketing and diaphragm sealing.



## Asbestos Fabric for Friction Service

A friction material of woven asbestos fiber impregnated with various oils and resins has been developed by the *Friction Div., Thermoid Co.*, Trenton, N. J. It is designed for use in oil-cooled power transmission equipment, such as clutches, torque converters, power take-offs and brakes. Danger of clogging of small ports in the oil system is said to be avoided since the material contains no wire or metal particles. The fabric can be bonded to metal plates with thermosetting resins and assembled in oil-cooled units alternately with metal pressure plates. Thickness ranges from 0.030 to 0.090 in. One piece, full ring diameters are available up to 12 in. o.d., but larger plates can be obtained by using segmented pieces.


# AL CHROMIUM-MANGANESE
# LOW-NICKEL STAINLESS GRADES

### WRITE FOR THE ASSISTANCE YOU NEED

1. **"TECHNICAL STUDIES #3"** . . . essential information on the composition, properties, fabricating methods and applications of AL chromium-manganese, low-nickel stainless steels. *Write for your copy.*
2. **TEST SAMPLES** . . . We'll be glad to supply engineering assistance, and actual samples of these 200-Series steels for testing under your processes and conditions.

**Address Dept. MM-76**

*Here is a direct answer to the recurring problem of nickel shortage.* For many users of chromium-nickel austenitic stainless steels, the new AISI 200-series of chromium-manganese low-nickel austenitic grades can be a source of immediate relief—and an avenue to the reduction and possible avoidance of nickel shortage problems in the future.

In many cases, you can switch directly from the older Type 301 and 302 grades to the new AL Stainless Type 201 and 202 steels, using the same fabricating processes and securing about the same results. There's nothing new to learn, and no loss in performance in practically all applications. In certain respects, these steels have better properties than the older materials and may be used to actual advantage in some cases.

We also produce low carbon grades of these chrome-manganese steels, arbitrarily designated Types 204 and 204L (similar to the older grades 304 and 304L) . . . as well as a lower-chromium, higher-manganese grade designated Type CM, which contains only 1% nickel. Allegheny Ludlum has pioneered in the development and application of these low-nickel stainless steels. We know what the new grades will do . . . let us help you put them to use. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

**For Stainless Steel in ALL Forms—call**

**Allegheny Ludlum**

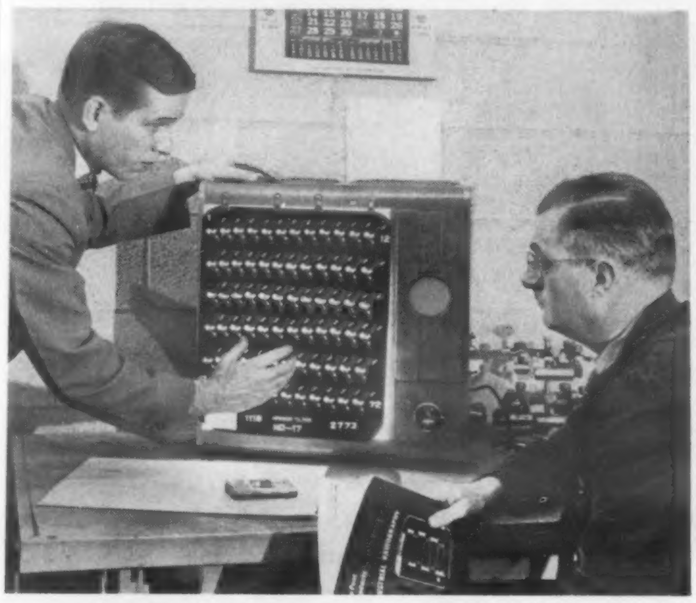
AL STAINLESS STEEL

WSW 5738

**Warehouse stocks carried by all Ryerson Steel plants**

**For more information, turn to Reader Service Card, Circle No. 504**

**Chief Metallurgist**, Paul L. Butler (right), and E. A. Christiansen, Du Pont Representative, examine casting. Radiographs made on Du Pont Type 506 N.I.F. help insure high-quality products at Arwood.



**Process Engineer** Ernest LaPlant (right) of Arwood's Tilton, N.H., Plant and Paul Colgate of Du Pont discuss x-ray exposure technique.

**Technician** Charles Davis prepares to expose castings using Du Pont Type 506 Fine Grai Industrial X-ray Film. Mr. Ernest LaPlant says, "Using Du Pont Film has practicall eliminated the danger of false interpretation of minute defects in small castings

# "For rapid x-ray inspection of precision castings ... Du Pont 506 N. I. F.* is tops!"

—says **Paul L. Butler,** Chief Metallurgist and Director of Research, Arwood Precision Casting Corporation, Brooklyn, New York

"We produce over 3,000,000 steel and non-ferrous alloy parts each year, and to make sure these castings are flawless, we depend on x-ray inspection using Du Pont 506 N.I.F," says Paul L. Butler of Arwood Precision Casting Corp., Brooklyn, New York. "It combines good contrast, stability and ease of handling... qualities that are a must in our work. And the packaging without interleaving paper has eliminated clean-up problems and increased the efficiency in our darkroom."

Robert Ritter, Inspection Supervisor, adds, "The wide latitude and fine grain structure of Du Pont 506 simplify interpretation—especially for small, intricate castings where high definition is absolutely necessary."

Process Engineer Ernest LaPlant of Arwood's Tilton, New Hampshire, Plant, says, "Our operation is primarily making parts by the investment-casting process. The tremendous latitude of Du Pont 506 makes it possible for us to come up with topflight radiographs, regardless of the type of castings we x-ray or differences in section thickness."

Mr. Butler concludes, "We used to stock several different kinds of film until we switched to Du Pont 506 in 1951. It has proved to be so versatile that we now use it exclusively!"

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... THROUGH CHEMISTRY

# DU PONT X-RAY PRODUCTS

FILMS • "PATTERSON" SCREENS • CHEMICALS

# CONTENTS NOTED

*A digest of papers, articles, reports and books of current interest.*

- *Stress corrosion cracking*
- *New iron-zinc plates*
- *Reinforced plastics springs*
- *Plastics strengthen rubber*
- *Mechanical properties of thorium*

## New Low Alloy Steels Resist Stress Corrosion

Among low-alloy corrosion-resistant steels, a group of chromium-aluminum steels developed in France seem to offer exceptional resistance to stress corrosion cracking—a characteristic which should permit their extensive use in industries such as chemical and petroleum.

Though not all the causes of intergranular attack have yet been established, it is clear that nonmetallic elements such as carbon and nitrogen do much to encourage it. It is not so much the quantity of these elements that matters as it is the distribution and size of the aggregates or constituents.

An article in last November's *Aciers Fins & Spéciaux* (French) points out factors causing stress corrosion cracking and describes the results of some work in France to determine the combined effects of stress and corrosion on some low alloy steels. Special emphasis is given to chromium-aluminum steels.

**Causes of stress corrosion**

Stress corrosion cracking is due to three factors: 1) external stresses near the yield strength, sufficient to bring about plastic deformation; 2) specific corrosion surroundings; and 3) alloy composition and structure that is liable to intergranular attack under conditions 1) and 2). In addition to external stresses, the presence of internal stresses, an unstable condition brought about by martensitic hardening or sudden cooling, is equally certain to cause intergranular corrosion. In attempting to reach a more stable state, steels undergo modifications which make boundaries between grains extremely sensitive to the action of certain reagents. The internal stresses are superimposed on external stresses and complete the rapid destruction of the crystalline structure.

Among other causes, surface decarburization and cold drawing in particular make steels sensitive to intergranular attack. Though aluminum-killed steels behave better than unkilled steels, unstable conditions caused by riveting, welding, decarburization or cold drawing in the presence of stresses near the elastic limit make these steels liable to cracking.

Extra-mild titanium steels (less than 0.08% carbon), with carbon and nitrogen fixed, no longer age after hardening or cold drawing. Though resistant to intergranular attack, they nevertheless undergo local attack such as pitting, and superficial attacks such as those common to unalloyed mild steels.

**Chromium-aluminum steels**

With a carbon content of less than 0.13%, the addition of 2-4% chromium produces a steel with a martensitic structure after hardening. Under stress and in the presence of nitrates the steel will crack. This same steel no longer hardens when 0.7-1.2% aluminum

### *A Primer on . . . .*
### Stress Corrosion Cracking

As pointed out in the accompanying digest, stress corrosion cracking is attributable to a combination of external stresses, specific corrosive environments, and a vulnerable alloy composition and structure. Fractures are initiated by selective corrosive attack at the grain boundaries of the materials.

In a low alloy steel, for example, the ferrite grain remains relatively unattacked when exposed to certain types of corrosive environments. However, the zones surrounding the grains (called intergranular joints or boundaries) are corroded rapidly. These zones, where precipitated compounds such as carbides and nitrides of iron are distributed at random, are starting points of dislocations. Between the nonmetallic precipitated compounds (cathodes) and the ferrite (anode) an electromotive force is formed, comparable to that of small electrical cells. The effect of stresses is to make the intergranular zones still more anodic and thus they tend to dissolve more rapidly than other zones in a given system.

Activity of these cells increases when an external force causes deformation of the crystalline network. Very fine cracks are formed in the most vulnerable and deformed areas. The section is weakened as a result of grooving, and the forces become more severe at the bottom of cracks. Cracking then proceeds more rapidly and finishes by spreading across the grains.

is added. The structure, after normal cooling from 1700 F (0.8-mm specimen in air, 4-mm specimen in water) consists of ferrite and carbides. After normalizing, mechanical characteristics of the steel are those of a solid solution of ferrite slightly hardened by the chromium and aluminum and reinforced by carbides which are dispersed in small or medium-sized granular aggregates, resembling pearlite in unalloyed steels. After rolling, typical mechanical properties of such a steel are: 64,000 psi tensile strength, 44,000 psi yield strength and 24% elongation.

In the presence of nitrates, the passifying effects of chromium and aluminum are quite evident. Due to the passive surface condition of the steel, pitting attack and general dissolution are much slower than for unalloyed steels or for low alloy steels containing chromium, titanium and aluminum. When a harder steel is required, small amounts of nickel and molybdenum can be used to obtain a bainitic structure. After normalizing, such steels attain a tensile strength of 100,000-150,000 psi, a yield strength of 50,000-100,000 psi and 12-16% elongation.

An important problem in the petroleum industry is the development of steels resistant to attack by hydrogen sulfide. Hydrogen sulfide attacks iron with the formation of iron sulfide and atomic hydrogen, which is dissolved in the chrystalline structure. Dissolved hydrogen embrittles the steel and reduces its ability to deform, its contraction and its elongation. Cold drawing accelerates speed of diffusion of hydrogen atoms, thus increasing the tendency to crack. Certain carbides, such as nickel and chromium, also favor formation of cracks and embrittle the metal.

A French steelworks has developed a 4.0 Cr-1.0 Al-1.0% Ni alloy with the minimum amount of carbon necessary for a tensile strength of 80,000-90,000 psi and a yield strength of 75,000-80,000 psi. Tubes of the alloy, after being treated to obtain a tensile strength of 90,000 psi, will flatten completely without cracking. Due to its composition and its sorbitic structure, the steel resists attack by hydrogen sulfide, even after cold drawing of the order of 10% with triaxial stresses.

## Reinforced Plastics Promising for Springs

Helical springs made of glass-reinforced polyester and epoxy resins have been produced and tested with surprising success. Most published information on spring materials deals with steels, copper or other types of metals, and use of nonmetallics such as plastics or rubbers for springs is relatively uncommon. There are, however, advantages which polymeric materials can provide for special-purpose springs.

### Plastics advantages

For example, plastics are nonmagnetic, have low thermal and electrical conductivity, have good strength-to-weight characteristics, and can be obtained transparent, translucent or opaque in a range of colors. In addition to these inherent characteristics, plastics can be molded directly to final dimensions without developing considerable internal stresses; whereas metal helical springs, after being formed on a mandrel, generally uncoil slightly, increasing in diameter and sometimes in length. On the other hand, plastics are more sensitive to time and temperature than metals.

The potential of reinforced plastics as spring materials has been studied by the National Bureau of Standards for the Ordnance Corps. F. W. Reinhart and S. B. Newman of NBS reported on results of the work in a paper delivered before the 11th Annual

## CONTENTS NOTED

Technical and Management Conference of the Reinforced Div. of The Society of the Plastics Industry, held February in Atlantic City.

**Specifications**

Though spring specifications can be quite detailed, a great deal of latitude was permitted in developing plastics springs. Specifications established for plastics springs were limited to the following:

1. Springs should be manufactured of any nonmetallic material other than wood.

2. They should be designed so that they can be easily fabricated by mass production methods.

3. They should be capable of functioning at any air temperature from −40 to 135 F.

4. They should be no larger than 2 in. in dia and 3 in. in height.

5. They should support a load of 25 ±5 lb at a deflection of 0.25 to 0.50 in.

6. Immediately upon release from the loaded and/or stressed position, springs should produce about 30 in.-oz of kinetic energy.

A large number of commercial resin formulations were screened to eliminate resins with unsuitable properties. Rapid evaluations of torsional rigidity and temperature sensitivity were obtained by testing resin rods. In general, polyesters were found to be more sensitive to elevated temperatures than epoxies, although the epoxy materials varied widely in this respect. On the basis of torsional moduli and temperature sensitivity, polyester and epoxy resins seem to be the most promising resins for spring applications.

Springs were molded by drawing resin-soaked glass fiber rovings through vinyl copolymer tubing and wrapping the loaded tubing in helix around mandrels of suitable diameter. Mandrel and tubing were then transferred to an air-circulating oven for curing. The tubing was subsequently removed.

**Results of tests**

Helical plastics springs with coil diameters of approximately

For more information, Circle No. 429 ➤

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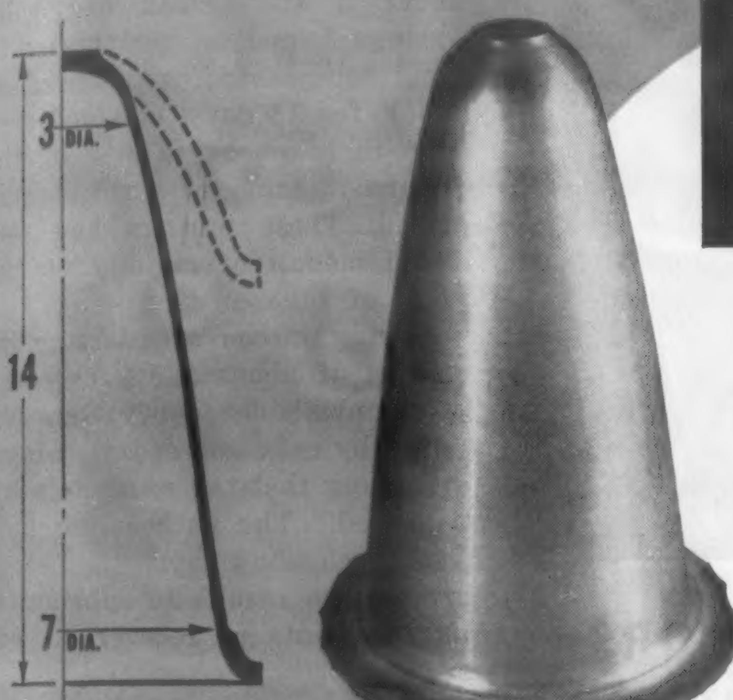
No. 429 ›

**HEMISPHERES TO 38" DIAMETER,** with 3/8" max. wall thickness, are readily formed on the Cincinnati Hydrospin. Part wall can be tapered or have constant thickness. The starting blank is a flat disk or dished preform. Almost any ductile metal can be used. Other machines available for parts and hemispheres larger than 38".

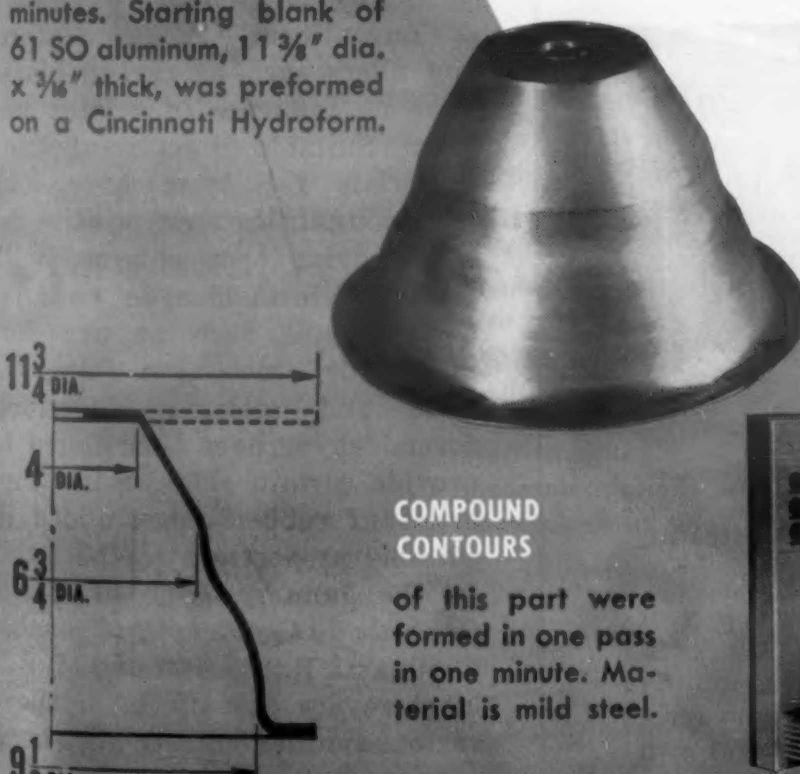



# complicated contours cost less by Hydrospinning!

**PARABOLIC-SHAPED PART** formed in one pass in two minutes. Starting blank of 61 SO aluminum, 11 3/8" dia. x 3/16" thick, was preformed on a Cincinnati Hydroform.

The parts shown here were formed by *tracer* Hydrospinning at substantial reduction in cost over that of previous production methods. These parts were produced in far less time . . . are more accurate . . . have increased strength with greater resistance to fatigue failure . . . required less material . . . and were made without compromising on material requirements.

If difficult-to-form contoured components are one of your production headaches, get the facts on Hydrospinning. Call in a Cincinnati Milling field engineer. For a detailed description of the process and machine specifications, write for new Bulletin M-1873-2.




**COMPOUND CONTOURS** of this part were formed in one pass in one minute. Material is mild steel.

CINCINNATI 42" x 50" HYDROSPIN

CINCINNATI **Hydrospin**

PROCESS MACHINERY DIVISION
**THE CINCINNATI MILLING MACHINE CO.**
CINCINNATI 9, OHIO, U. S. A.

CONTENTS NOTED

1 in. and wire diameters of 3/16 in. were formed from glass-reinforced epoxy resins cured with m-phenylenediamine. A spring of this type 2 in. long deflected ½ in. under a static load of 25 lb. Springs 3 in. long, compressed to their solid length and stored at 135 F for 13 days, retained over 5 in.-lb of energy (40% of the original) at the end of the storage period. These springs had torsional moduli of rigidity on the order of $1.0 \times 10^6$.

During the course of testing, increases of about 120% over the initial available energy were obtained by retesting epoxy springs, indicating that the epoxies "work tempered." The authors conclude that preloading springs before using them results in substantial improvements in recoverable energy.

## Reinforcing Rubber with Synthetic Resins

Conventional rubber-reinforcing fillers such as carbon blacks have no influence in a latex medium. Suitable direct reinforcing materials for latex have long been sought, the first positive results having been obtained with resorcinol-formaldehyde resins. Other resins such as urea-formaldehyde, melamine-formaldehyde and melamine-resorcinol-formaldehyde have been found to provide certain changes in properties of rubber, when added in suitable proportions to the latex. In the January issue of *Revue Genérale du Caoutchouc* (French), C. Pinazzi, R. Cheritat and M. Billuart review the effects of these various synthetic resins when used as reinforcement for rubber.

### Defining effects

The authors first define their method of evaluating reinforcing action of the materials. They admit there is a lack of clear, meaningful designations which can be used to describe reinforcing action. However, they arbitrarily select effects of reinforcing agents


For more information, turn to Reader Service Card, Circle No. 322





## CONTENTS NOTED

on hardness, modulus, tear resistance, permanent set and mechanical softening as descriptive of the strengthening value of the resins.

A reinforcing agent should improve hardness, modulus and tear resistance. Such improvements are generally accompanied by an increase in permanent set, which should be kept as small as possible. After mechanical work, stabilized properties of a reinforced material should be better than mechanical properties of the same material unreinforced.

With direct latex reinforcement by resins, hardness, modulus and tear resistance increase considerably, while permanent set remains at a low level. On the other hand, mechanical softening is more prevalent than with carbon black-reinforced rubber having similar initial hardness.

### Effects of resins

**Resorcinol - formaldehyde** — Compared with pure gum rubber tear resistance and tensile strength are considerably increased. Some typical mechanical properties of a 7.5% resin-rubber blend are: 6400 psi tensile strength, 1200 psi modulus at 500% elongation, 728 lb/in. tear resistance and 57 Shore hardness.

Mechanical properties of the blends are affected both by the molecular formaldehyde-resorcinol ratio and by the relative proportion of dry resin to dry rubber. Best results are obtained when the first ratio is held to approximately one, and the proportion of resin in the rubber is kept under 15%. Above 15% resin, blends become rather stiff, and elastomeric properties are considerably lowered.

Mechanical properties of compounds with less than 15% resorcinol-formaldehyde resin are similar to those of carbon black-reinforced rubber of the tire-thread type. However, moduli are lower and hardness losses after mechanical work are more marked than for carbon black-reinforced

# TAYLOR

Laminated Plastics
Vulcanized Fibre

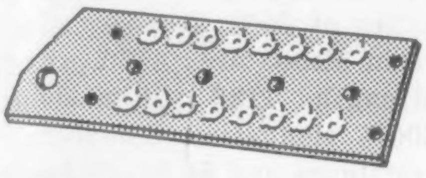
# Shop Talk

TAYLOR FIBRE CO.

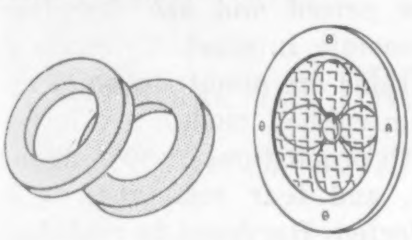
*Plants in* Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • VULCANIZED FIBRE • POLYESTER GLASS ROD

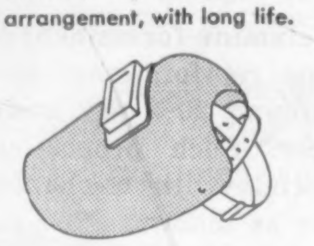
## Tips for designers



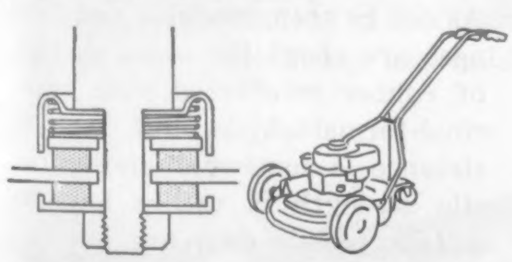
***Terminal board*** for a complex circuit in an electronic spectrophotometer instrument is made of Taylor Grade LE laminate . . . selected for its insulating and mechanical properties.



***Large exhaust fans*** use Taylor paper base phenolic washers to help absorb thrust . . . an inexpensive arrangement, with long life.



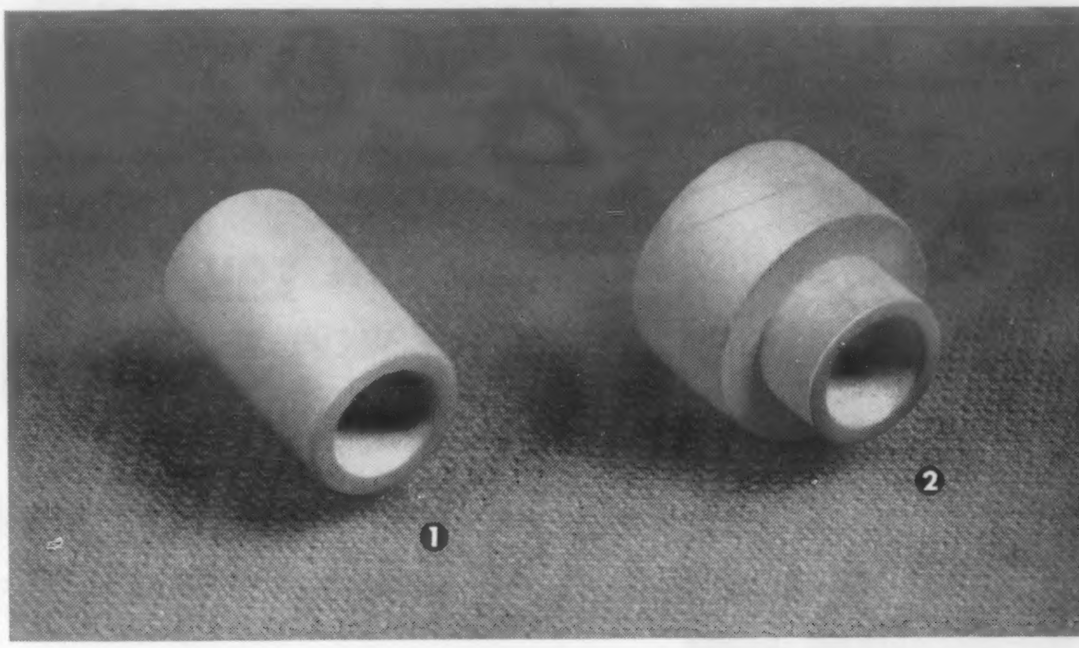
***Welders' helmets*** are fabricated from tough, durable Taylor vulcanized fibre . . . readily formed to many desired contours.



***Rotary lawn mower*** utilizes abrasion resistance of Taylor phenolic laminate washer in slip-clutch attachment of drive shaft to cutting blade.

**TAYLOR FABRICATING FACILITIES**

Your production problems can often be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced by having Taylor fabricate finished parts of vulcanized fibre and laminates to your specifications. Efficient, modern facilities are ready to serve you. Write to Taylor about your specific requirements.




Chosen for its mechanical strength and electrical insulation, this Taylor laminated tubing provides an economical means for making (1) an ignition breaker arm bushing and (2) a distributor terminal bushing.

## Strength plus electrical insulation, available in Taylor laminated tubing

Among the most versatile basic materials available to the designer, Taylor laminated plastics are constantly finding new applications . . . in new products for future markets and as replacements for parts in current production.

Widely used in flat sheets for the fabrication of parts for electrical components, Taylor laminates are also available in tube form. This makes them applicable to an even greater number of parts . . . such as bushings, guides, shafts, and housings for resistors, thermistors and fuses. The tubes are supplied with inside diameters as small as $\frac{3}{32}$". Standard lengths are 36" or 49", depending on grade, inside diameter and wall thicknesses.

Included in the broad selection of Taylor laminated tubing are a great variety of different grades . . . paper, fabric and glass bases combined with special formulations of phenol, melamine, silicone and epoxy resins. Each grade offers electrical and physical properties which qualify it for a specific application at a reasonable price.

Of particular interest to economy-minded designers and production managers is the fact that this laminated tubing permits the use of a part for a mechanical application without the need for extra electrical insulation.

Plan to take greater advantage of Taylor laminates . . . in tube, sheet and rod form . . . either in your present products or in those which you are now designing. Call or write for a discussion of your specific requirements.

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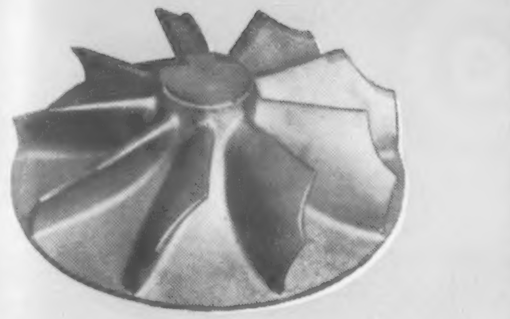
## CONTENTS NOTED

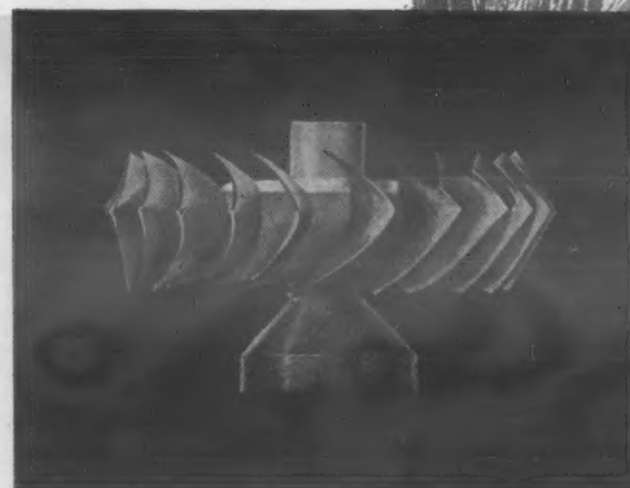
material. Moreover, mechanical properties seem to be unfavorably affected by higher temperatures.

**Urea-formaldehyde** — Mechanical properties of rubber are less strongly modified by such resins than by resorcinol-formaldehyde resins. Typical mechanical properties of 30% urea-formaldehyde resin blends are: 4750 psi tensile strength, 1136 psi modulus at 500% elongation, 336 lb/in. tear resistance and 56 Shore hardness. Though reinforcing effects are less than with either resorcinol or melamine resins, urea resins are low priced and are therefore of economic interest. Ultimate elongations are about the same as for gum rubber, moduli are increased with proportions of 30% resin and up, and tear resistance is little affected. Hardness is considerably increased. Blends are white and can be colored.

**Melamine-formaldehyde** — Optimum reinforcement takes place at around 20% dry resin to dry rubber. Such proportions yield materials with mechanical properties as follows: 3700 psi tensile strength, 1000 psi modulus at 500% elongation, 530 lb/in. tear resistance, and 58 Shore hardness. As can be seen, modulus and hardness are about the same as those of rubber reinforced with resorcinol-formaldehyde, but tear resistance is somewhat lower. Tensile strength is rather low, but usually tensile data are not very significant for design purposes. These blends are also white and can be colored.

**Melamine-resorcinol-formaldehyde** — The resin is produced by precondensing separately melamine-formaldehyde and resorcinol-formaldehyde. Such rubber compounds are characterized by high modulus and hardness values, and tear strengths similar to those of resorcinol-formaldehyde blends. The melamine seems to produce a stronger crosslinkage providing better heat resistance. Typical properties of blends containing 8% resorcinol-formaldehyde and





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MICROCAST PRECISION CASTINGS PROCESS

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## CONTENTS NOTED

5% melamine-formaldehyde are as follows: 4200 psi tensile strength, 570 psi modulus at 500% elongation, 675 lb/in. tear strength and 73 Shore hardness.

### Effect of Impurities on Thorium Metal

Since thorium metal prepared by any process always contains some impurities, it is essential to determine the effect of these impurities on mechanical properties of the material. This information can then be used in specifying limitations on these impurities in order to obtain consistent end properties in the metal.

Of course, elements with high cross-sections for neutron capture must be kept at low concentrations if the metal is to be used in a nuclear reactor. Other elements such as aluminum, beryllium, carbon, nitrogen and oxygen, however, have small neutron cross-sections and the allowable limits of such impurities are established primarily by their effects on chemical and mechanical properties.

Results of an investigation into the effects of these elements on mechanical properties of thorium are given in a paper by D. T. Peterson, R. F. Russi and R. L. Mickelson, all of Iowa State College, contributed by the American Society of Mechanical Engineers to the Nuclear Engineering and Science Congress last December. Thorium castings were made containing additions of beryllium, aluminum, oxygen, nitrogen and carbon. As-cast, hot-rolled and hot-swaged samples were prepared from these billets and were annealed at 1475 F for 15 hr under vacuum.

The authors report that mechanical properties of thorium in the fully annealed condition depend primarily on carbon content. Hardness, yield strength and ultimate tensile strength increase with increases in carbon content. These properties are not appre-

For more information, Circle No. 446 ›

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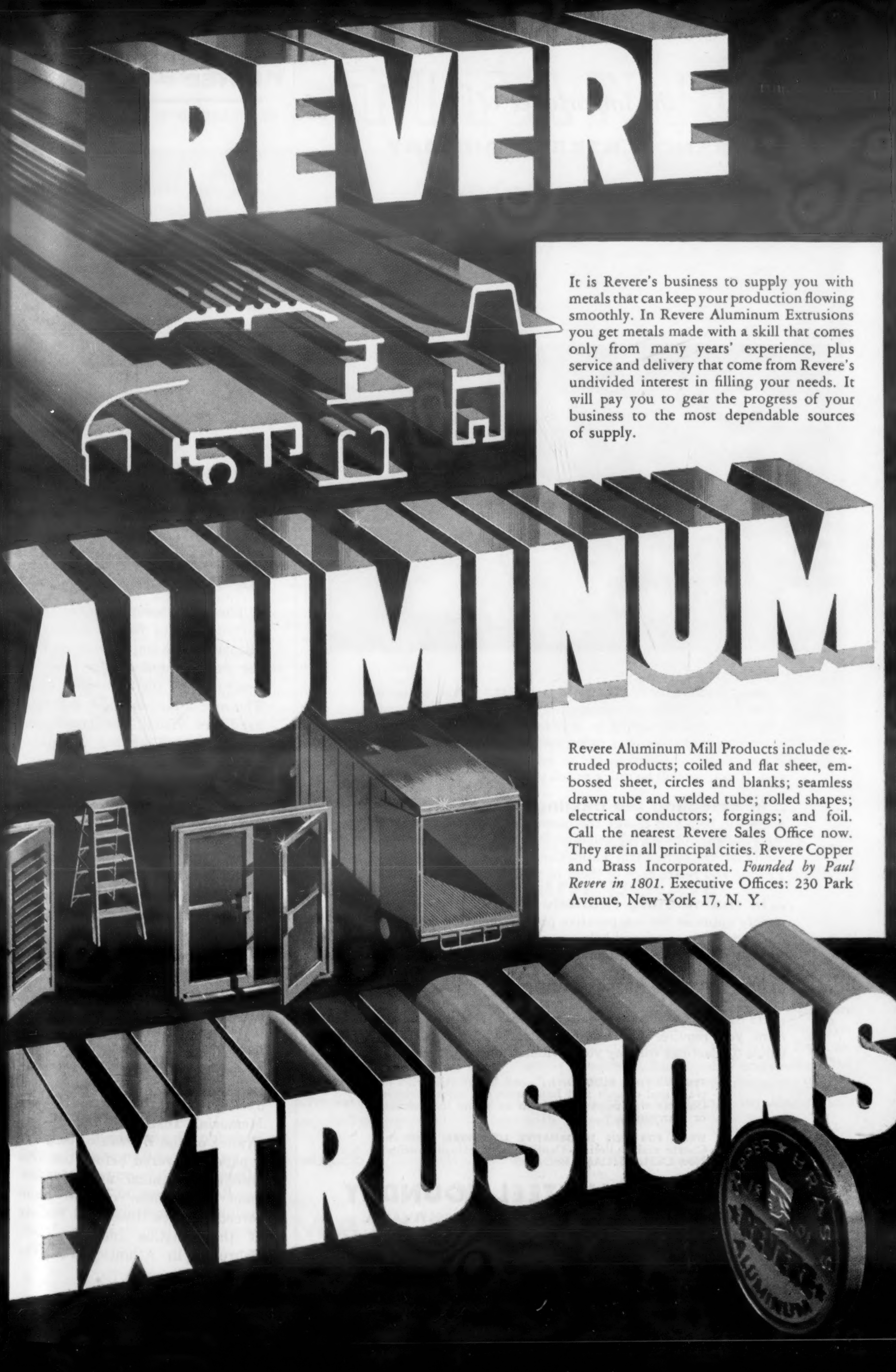

ciably affected by additions of oxygen, nitrogen, beryllium or aluminum. Fabrication methods do not seem to influence these mechanical properties.

Impact strength is greatly decreased by addition of carbon. Additions of oxygen do not affect thorium's excellent ductility, but nitrogen, aluminum or beryllium slightly decrease impact strength of as-cast bars. Impact strength is also decreased by hot-rolling, particularly in samples broken perpendicular to the rolling direction. Welding behavior does not seem to be a function of the concentration of these impurity elements.

## Non-Destructive Tests for Plastics

The increasing use of reinforced plastics for structural applications has emphasized the need for development of effective non-destructive testing techniques. The major test methods currently used are visual, for translucent laminates, and tapping, for opaque laminates. Instrumentation is certainly desirable to aid inspectors in their work.

### The ideal instrument

An ideal non-destructive test instrument for laminates would have the following characteristics: 1) capability of detecting delamination, porosity, dry spots, resin segregation and incomplete cure; 2) ability to measure laminate thickness and resin content; 3) ability to penetrate laminate to a minimum of ½ in. in depth, and to be operated from side only; 4) portability and ruggedness; and 5) economy and ease of operation.

These factors were pointed out by A. J. Schwarber, Jr., of Battelle Memorial Institute and W. R. Graner of the Bureau of Ships in a paper delivered before the 11th Annual Technical and Management Conference of the Reinforced Plastics Div. of the Society of the Plastics Industry, Inc., February in Atlantic City. The

MALLORY·SHARON reports on TITANIUM

*This typical punched card records ingot number, specimen number, direction of test, rolling temperature, finish rolling temperature, annealing temperature, annealing time, quenching medium, ultimate strength, yield strength, percent elongation. Approximately 25 cards are needed to record all the facts on each heat.*

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Thus, fast answers can be obtained to researchers' questions, such as . . . what are the comparative strengths and ductilities of weldable alloys? . . . how do variations in titanium sponge hardness affect alloy strength? . . . what are the effects of heat treatment on bend characteristics?

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MALLORY Ti SHARON

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## CONTENTS NOTED

authors summarized results of a survey carried out by Battelle for Navy of existing techniques and procedures, as well as the various energy forms used by the equipment.

**Current tests**

The authors described the various test methods and reached the following conclusions:

1. **Visual**—At present visual inspection is still the best nondestructive test for laminate quality when the materials concerned are translucent.

2. **Tapping**—A skilled inspector, using "tapping" tests, can locate suspicious areas in opaque laminates by noting the duller sounds obtained when tapping these areas. An electro-mechanical tapping device may be effective for checking the bond between outer skins and cores in honeycomb sandwich materials.

3. **Penetrant** — Dye penetrants can detect laminar defects occurring at edges of a panel, and will also show surface porosity and crazing.

4. **Radiography**—Internal density variations, porosity and cloth folds can be detected, but the method is usually ineffective for locating delaminations. Radiography is costly and time consuming.

5. **Ultrasonics** — At present, pulse-echo techniques are ineffective for laminate inspection. Through-transmission ultrasonic tests are quite effective for locating internal defects such as delaminations, dry spots and gross porosity in small laminate panels. Operation at 1 mc is superior to that at 5 mc.

6. **Resonant frequency** — One instrument tested effectively measures laminate thickness within 8% accuracy. It also determines depth of a delamination defect to the same degree of accuracy. Work now being done on another type of instrument to replace a quartz crystal with a barium titanate transducer may enable it to effectively measure laminate thickness

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These Norton "Hot Rods" have already lasted over 11,000 hours in operation without a single failure or replacement. The spare elements bought nearly two years ago with the furnace have never been used.

This is the kind of designed-in service we like.

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T. H. Speller,
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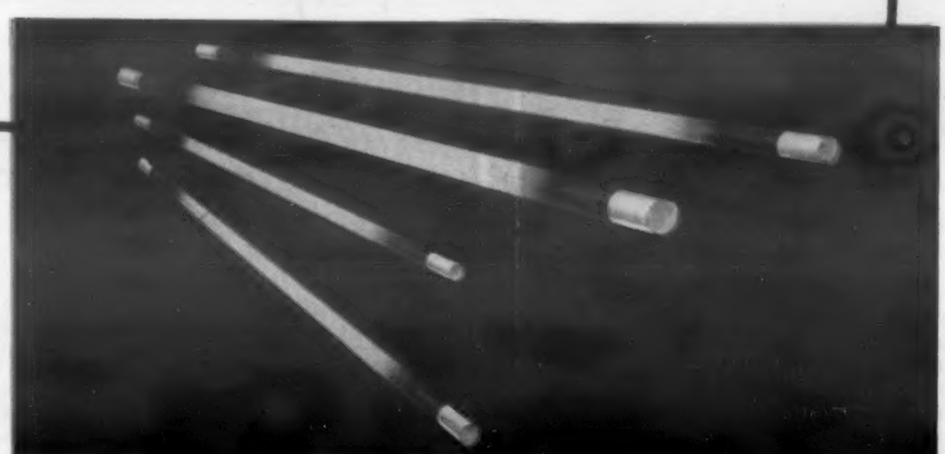
THS/ljk

*At the Plant Of General Riveters, Inc.*, in Buffalo, N. Y., this electric furnace, with Inconel muffle and Norton CRYSTOLON* heating elements, is used in heat treating, to bring out the magnetic properties of Vicalloy metal, a component of hysterises type clutches for airborne equipment. Designed and built by the Edward G. Pierson Co. of Grand Island, N. Y., the furnace has given maintenance-free service since its installation over two years ago. The original "Hot Rods" installed are still delivering top performance.



***CRYSTOLON heating elements***, or "Hot Rods" are a typical Norton ℞ — an expertly engineered refractory prescription for greater efficiency and economy in electric furnace and kiln operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes and interchangeable with your present rods.

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You save in element costs, because you use far less "Hot Rods." Many plants report they outlast other non-metallic heating elements *up to 3 to 1!* This also means less maintenance time spent in changing elements and voltage taps. Also, "Hot Rods" heat more uniformly, due to their slow, evenly matched rate of resistance increase. This helps protect product quality and maintain a smooth production flow.

For further facts on how "Hot Rods" can help improve your furnace operations and cut costs, send for booklet, "*Norton Heating Elements.*" NORTON COMPANY, Refractories Division, 343 New Bond Street, Worcester 6, Mass.

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and locate delaminations.

7. **Dielectric test** — Laminate thickness can be measured effectively from one side of the work piece by means of dielectric tests. They can also be used to quickly determine resin content of laminates if the thickness is relatively constant. Under certain conditions resin concentrations or dry spots can also be detected.

## Iron-Zinc Alloy Electroplate

Iron-zinc alloy plates produced by a process developed by the British Iron and Steel Research Assn. are showing great promise as protective and decorative finishes for steel. The process, developed by the British Iron and Steel Research Assn., was first announced last year. Latest information on the plates and their properties appeared in an article by F. W. Salt in the January issue of *Electroplating and Metal Finishing* (British).

The alloys can be plated with compositions covering the range of 6 to 90% zinc. Composition of the alloy deposit is governed by the iron-zinc ratio in the bath and by its pH value. Over a considerable range the iron-zinc ratio in the alloy is directly proportional to that of the bath.

The plates show good adhesion to steel. Coated sheet or strip can be substantially deformed without damage to the coatings. Rates of deposition are high in all cases, particularly in the 35 zinc-65% iron alloys which can be plated at the rate of 1 mil in 5 min.

**General properties**

Hardness of deposits depends on zinc content, and ranges from 553 DPN for 3% zinc to 165 DPN for 90% zinc content.

Electrode potentials of the alloys (on the hydrogen scale) in N/10 potassium chloride at room temperature range from −0.35v for 3% to −0.73 for 90% zinc. Since the potential of the steel


◄ For more information, Circle No. 384

Closeup of mandrel, Ampco-coated steel balls fill tube during bending, prevent walls from collapsing.

Completed bend in Pines Precision Bending Machine.

# *Pines Engineering*
# licks "impossible" job

***. . . bends ultra-thin stainless tubing***
***. . . cuts airplane costs $14,000***
***thanks to* AMPCO* METAL**

AIRCRAFT engineers said that cold bending of thin-wall tubing sections for engine and airframe components was impossible — that it couldn't be done. But Pines Engineering Co., Aurora, Illinois, went to work anyway It developed a precision bending machine that makes smooth, sharp bends to 10″ centerline radius in up to 5″ diameter x .025″ wall stainless tubing — bends that are cutting airplane costs up to $14,000 each.

Pines selected Ampco Grade 20 wiper dies and Ampco-coated mandrels for their new precision machine to resist the tremendous pressures developed in this bending operation. Here's what they say:

"Ampco eliminates the problem of pickup on the mandrel and wiper die when bending stainless steel tubing. And Ampco provides a hard-wearing surface that enables the production of thousands of bends before dies have to be refitted."

And if you draw, form, or bend stainless, pickled carbon steel — or many other metals — here's what *you* get with Ampco dies:

**Little or no pickup.** You eliminate all the expense of redressing steel dies — redressing that is necessary because of scratching, galling, or pickup. Idle time is cut — and your line keeps moving at top production.

**Low finishing costs.** You end galling, loading, scratching, die marks. No more problems with big scrap losses. You reduce expensive finishing time.

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D-39A

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## CONTENTS NOTED

base is approximately —0.25v, for most of the alloys should provide steel with cathodic protection against corrosion. Corrosion resistance tests run on a range of electrodeposited iron-zinc alloys indicate that alloys of 40 to 60% zinc provide corrosion resistance at least equal to and often better than pure zinc.

The alloys show good smoothing action, particularly those with low zinc content. All of the alloys can be plated with an attractive gray matte finish and some, such as 6% zinc, can be deposited as bright finishes.

### Specific alloys

Specific zinc-iron alloy deposits described by the author are:

**6% zinc (bright)**—Plates at a rate of 1 mil in 10 min. Bath has very good smoothing action. On a steel base with an average roughness of 20 microinches, the surface roughness of the deposit is about 7 microinches. An inexpensive plate, it can be applied to a rough steel surface to decrease the amount of polishing prior to further plating. Its corrosion resistance is not significantly greater than that of mild steel.

**16% zinc**—Plates at a rate of 1 mil in 7 min. Deposit has a matte finish and does not corrode easily indoors. In view of its high hardness it could serve to replace nickel in electrotypes. The combination of wear resistance and some corrosion resistance would make it a good coating for many industrial and domestic products.

**35% zinc**—Plates at a rate of 1 mil in 5 min. Coatings have a matte finish and good corrosion resistance. The alloy should prove useful as a base for painted coatings on steel since it would provide cathodic protection at pores in the paint film and would not react with paint as readily as zinc.

**60% zinc (bright)**—Plates at a rate of 1 mil in 8 min. Though the plate is not fully bright as-deposited, it can be brightened by a small amount of buffing. The bright appearance is maintained indoors without tarnishing. The

# TIN'S SPECIAL PROPERTIES IMPROVE QUALITY, CUT COSTS, IN WIDE RANGE OF NEW APPLICATIONS

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In almost every American industry, the special properties of tin are making important new contributions today in the competitive race for product improvement. And Straits Tin from Malaya is the most widely used brand.

Tin wets metals readily, flows easily, adheres firmly and has a relatively low melting point. Tin is, of course, the key constituent of solder, and today improved equipment and processes are making solder still easier and more economical to use.

Tin has excellent antifriction qualities, conformability, and good embedding characteristics. It has long been invaluable as a bearing metal, and new tin bearing alloys — such as 20% tin-aluminum — are now producing excellent results in actual performance tests.

Tin has the property of hardening and strengthening copper twice as effectively as zinc, and provides much better resistance to corrosion.

Not only is tin one of the world's most important metals, it is now also one of our most useful chemicals. Tin compounds — as stabilizers, opacifiers, antioxidants — are currently being used in products ranging from plastics to toothpaste.

And most important of all: Tin is economical to use in any application. For just a little tin can do a lot of work.

There can never be a real substitute for tin. No other metal does so many different kinds of jobs so economically and so well. Whatever *your* product or process may be, a careful reappraisal of the properties of Straits Tin may show you new ways to improve quality and cut costs.

## STRAITS TIN NEWS & NOTES

In 1955 Malaya mined 36% and smelted 43% of the free world's tin. Malaya's largest lode mine, in the State of Pahang, has 200 miles of underground workings.

★

Did you know that 500 different food products are now preserved in tin cans? And the list is steadily growing. Soft drinks and wine, for example, now come in cans. Also, of course, many non-food items — including even plastic flooring and Geiger counters. Currently, over 90% of the tin used for cans is Straits Tin from Malaya.

★

Nature stored tin ore (cassiterite) in Malaya's mountain ranges millions of years ago. Present alluvial deposits are the result of heavy tropic rains washing this ore down into Malaya's river beds and valleys. This process, of course, is continuing. Geologists say no end is in sight to Malaya's tin reserves.

★

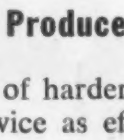
The recently discovered method of electroplating bright tin-nickel provides for the first time an important tarnish-resistant alternate to chromium on nickel-copper. With 65% tin content, tin-nickel is both more corrosion resistant and more attractive in color than chrome.

★

The value of Malayan tin output in 1953, about $110½ million, was one-fifth the value of that year's U. S. copper production, slightly less than U. S. zinc production, and one-third more than U. S. lead.

---

**A 20-page booklet gives an informative report on Straits Tin and its many new uses today. "Tin News," issued monthly, covers important current developments in the production, marketing and use of tin. We'll be glad to send you both if you'll send us your name and address.**

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## CONTENTS NOTED

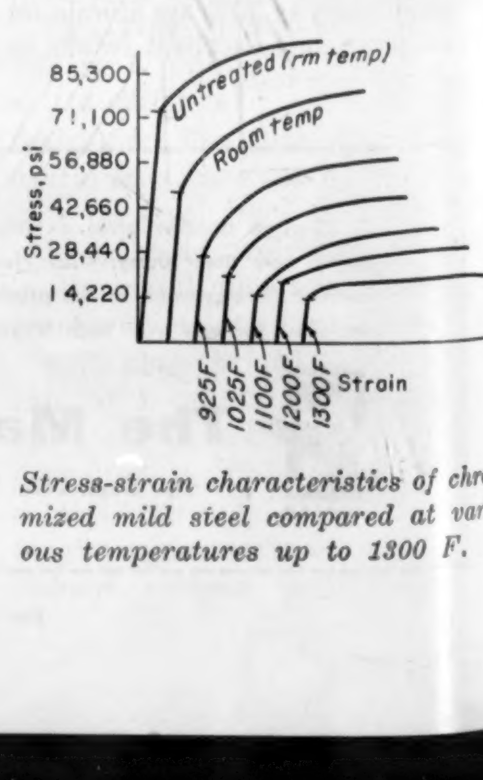
plate can be chromium plated readily. Bath has appreciable smoothing action as indicated by its bright appearance when deposited on an etched steel base. Deposit can be soldered easily and could be used to replace zinc and cadmium coatings on such products as radio chassis. Throwing power of the bath is comparable with that of a bright nickel bath.

**65% zinc**—Plates at a rate of 1 mil in 5 min. Deposit has a smooth, matte, pit-free finish. It is suitable for protection against atmospheric and possibly marine corrosion.

### Chromizing for Corrosion Protection

Many means are used to minimize corrosion losses. Chromizing, by no means a cure-all, does offer an economical, practical solution to many corrosion problems. Chromizing can be carried out by most factories with standard equipment at a cost of two to three times that of pack curburizing.

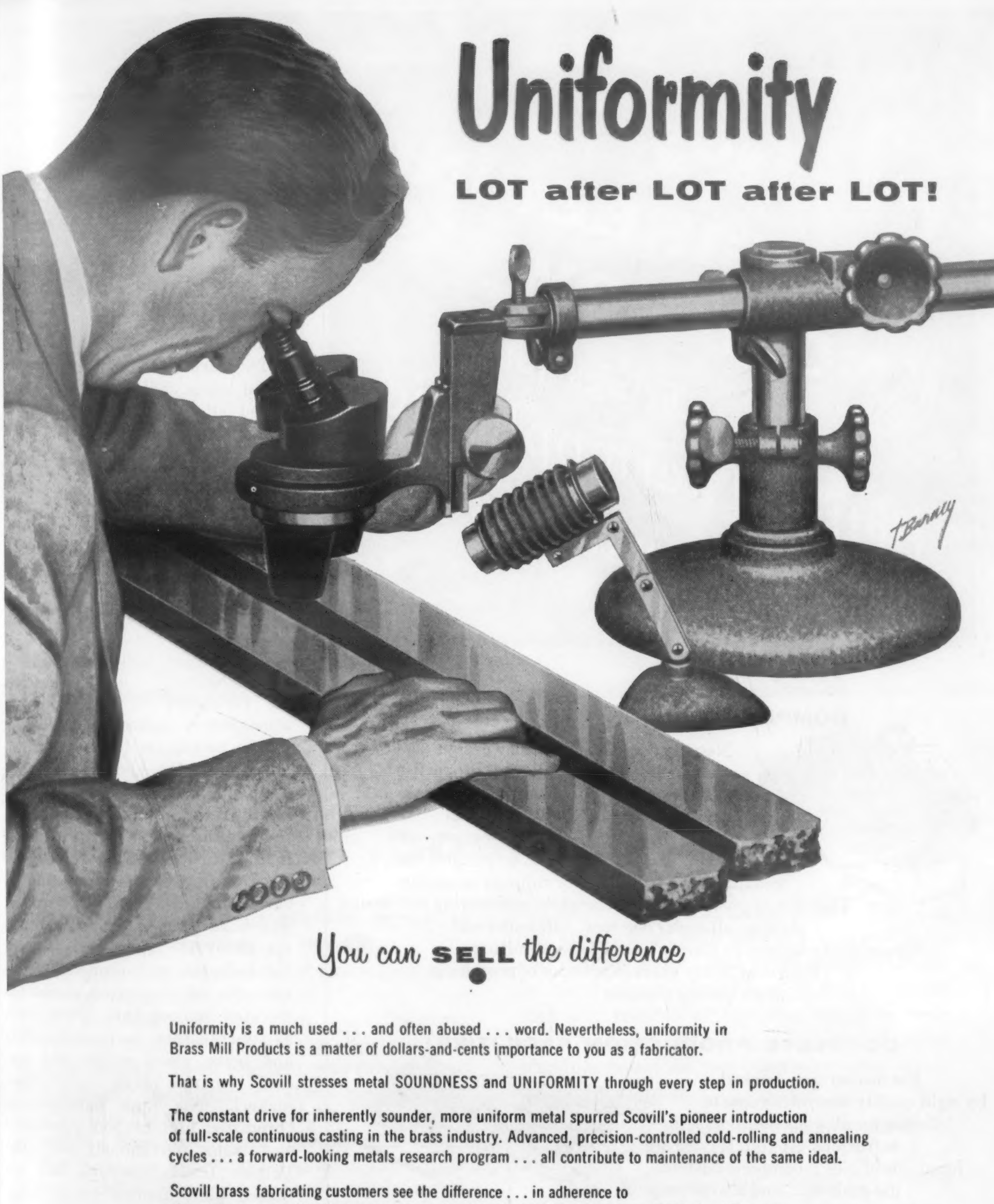
In last December's *La Technique Moderne* (French), J. Borgnon reviewed developments in chromizing of ferrous metals. The three main processes are based on deposition of chromium from halogen compounds in a hydrogen atmosphere. The German B.D.S. process uses chromium chloride and is limited to special low-carbon titanium-containing steels. The French O.N.E.R.A. process




*Stress-strain characteristics of chromized mild steel compared at various temperatures up to 1300 F.*

# Uniformity

## LOT after LOT after LOT!

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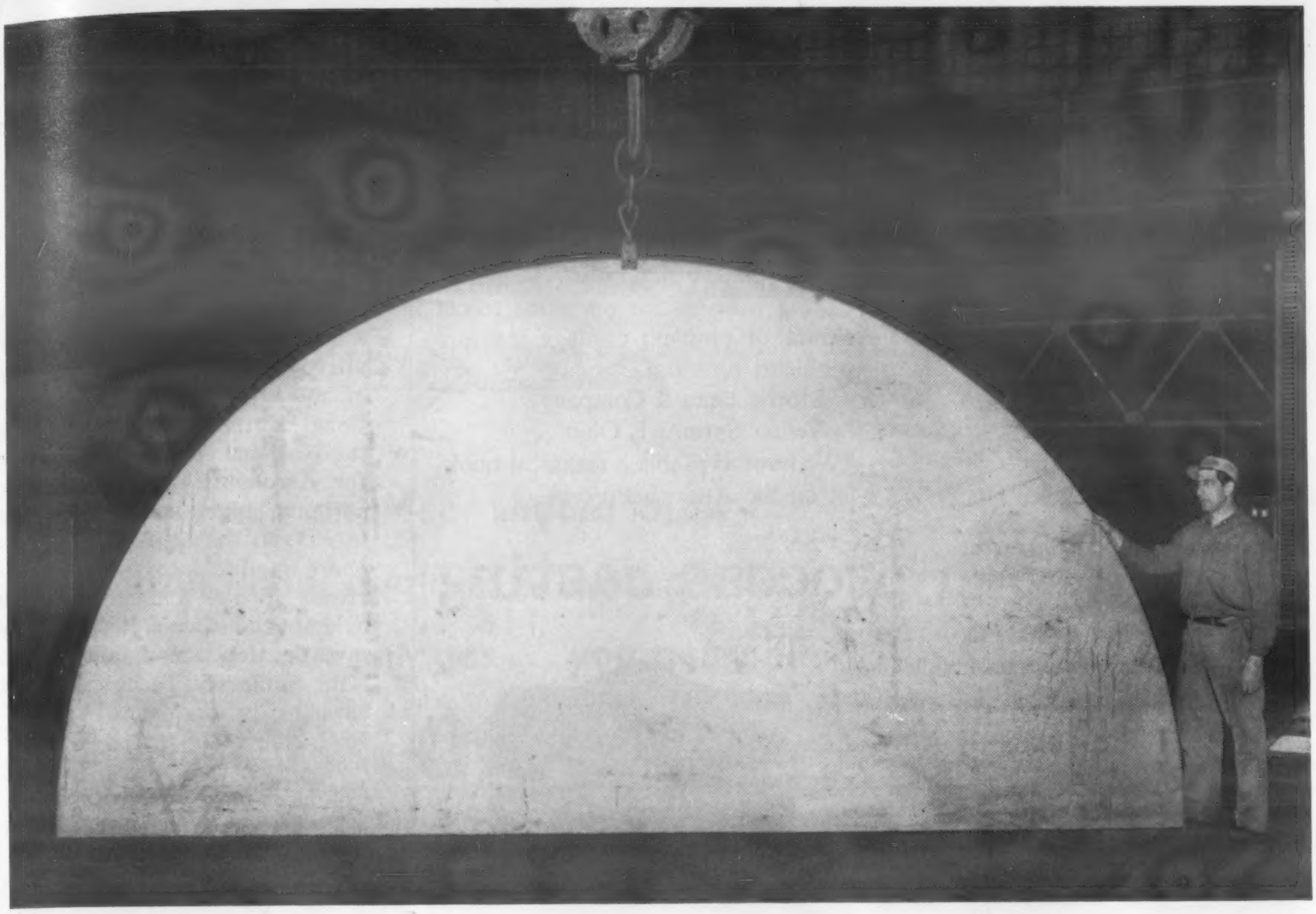
utilizes chromium fluoride. The British D.A.L. process uses iodine (ammonium iodide) as a catalyst. The latter is used commercially in France, the United States, Australia and Canada. Any ferrous metal, including cast iron, can be chromized by this pack-chromizing method.

The carbon content of the material being chromized has a profound effect on the results. As carbon content increases, depth of case decreases but case hardness increases—up to 2000 Vickers for the higher-carbon materials. Alloying elements, at least up to about 3%, have little influence on chromizing. The chromized layer of low-carbon steels is ductile and can be formed and welded.

This chromized layer is capable of resisting industrial atmospheres as well as many chemicals. Its resistance to sulfur-bearing atmospheres makes it interesting to the petroleum industry. Chromized steels show negligible scaling up to 1560 F and are highly resistant to thermal shock, though there is no improvement in high-temperature strength.

Chromized parts are finding varied applications. The Germans, who have been using this method for about 15 years, have proved the technical and economical advantages of chromized steels for elevated temperature parts such as superheaters, furnace supports and belts, glass molds, and aircraft spark plugs (chromized nickel). The high hardness of chromized high-carbon steels and cast irons, particularly with the British D.A.L. method, has extended their application to many tools such as files and woodworking tools. Aircraft bolts and textile mill parts are also typical of uses involving resistance to atmospheric corrosion. The dairy industry has long recognized the value of chromized parts. They are excellent for valves since their friction characteristics are better than those of solid stainless steels.

*(More Contents Noted on p. 220)*



## CONTENTS NOTED

### How Oxygen Affects Enamel Adherence

Oxygen has been found to play a definite role in the adherence of vitreous enamels to iron. Results of an investigation by the National Bureau of Standards for the National Advisory Committee for Aeronautics reveal that, for optimum adherence, any decrease in oxygen in the furnace atmosphere requires a corresponding increase in the amount of cobalt oxide in the enamel. Results of the investigation are detailed in an NBS Summary Technical Report covering work done by A. G. Eubanks and D. G. Moore.

Enamels containing 3.2% by weight or more of cobalt oxide develop a weak but definite bond to ingot iron in furnace oxygen concentrations as low as 0.02% mole. With smaller amounts of cobalt oxide, more oxygen is required in the furnace atmosphere for development of an appreciable bond. The investigators conclude that cobalt oxide in some way supplies or facilitates the supply of some of the oxygen to the bond. This conclusion appears to be substantiated when the amount of cobalt oxide is plotted against adherence index for specimens fired in low oxygen concentrations. Extrapolation of this curve indicates that cobalt oxide-free coatings have an adherence index of zero.

There also seems to be a correlation between surfaced roughness and adherence of the enamel. Adherence usually increases with increasing roughness. The roughening is believed to be caused by a galvanic corrosion mechanism. Cobalt ions present in the coating layer tend to plate out of the molten enamel electrolyte as metallic cobalt onto the more electronegative areas of the iron surface. The tiny galvanic cells thus formed cause selective etching of the iron surface if the specimen is fired in an atmosphere containing a sufficient amount of oxygen.

There is additional evidence, however, which indicates that

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**A** new group of product improvements are springing almost daily from this new plastic foam. Already Nopco has more than 50 Lockfoam types—each a formula that gives exact balance of foam qualities needed for a specific job. This foam "*know-how*" is ready to tailor foam to *your* special needs—to create a special Nopco Lockfoam that gives the exact and predictable performance you want... yet can be mixed and applied in your own plant.

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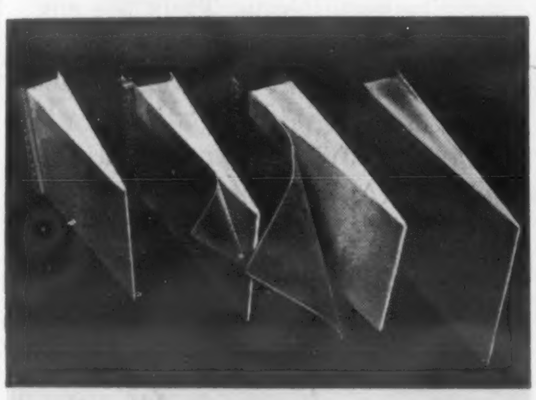
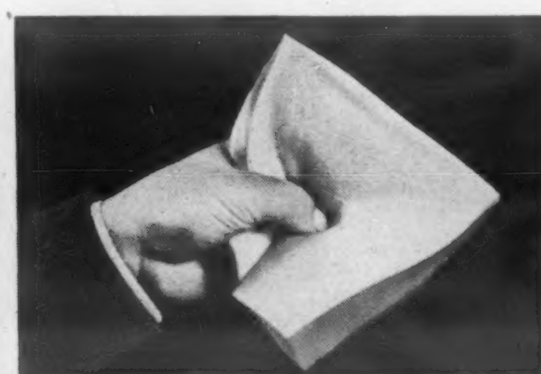
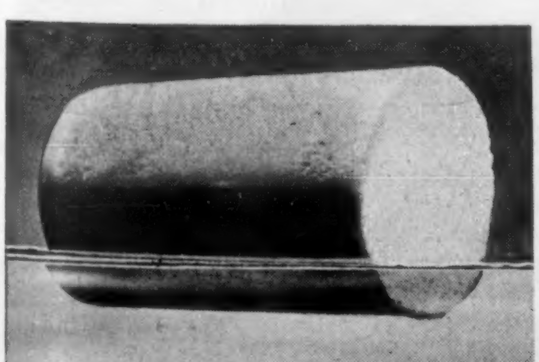


**STRENGTH WITH LIGHT WEIGHT!** In tests, standard aero control tab failed at 300,000 cycles. Duplicate tab filled with Nopco Lockfoam was still going strong at 900,000 cycles! In actual flight, Nopco Lockfoam helps reduce resonant vibration too!

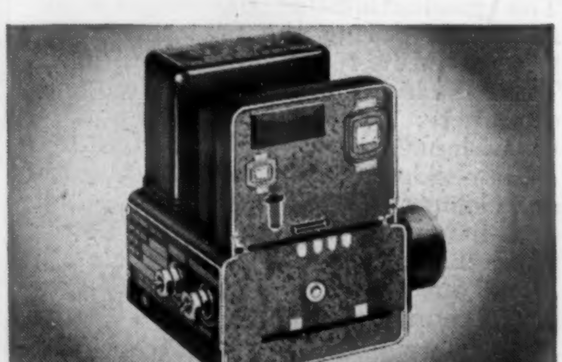
**NEAR PERFECT RADAR TRANSMISSION!** Nopco Lockfoam is the most widely accepted core material for aircraft and guided missile radomes.



**FLEXIBLES WITH BUILT-IN SAFETY!** Because of its "dead" characteristics and high energy absorption properties Lockfoam is ideally suited for automotive crash pads, helmets, packaging and shock mountings.



**LOCKFOAM FLOATS!** Lockfoam's unicellular construction provides excellent buoyancy and yet is unaffected by such liquids as gasoline, greases, aromatic solvents. Displacement varies inversely with changes in density.



**POTTING WITH LOCKFOAM!** Following combination of properties make Lockfoam ideally suited for potting... Low dielectric constant and tangent losses—complete cavity filling—lightweight—moisture resistant.

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PLASTICS DIVISION
HARRISON, NEW JERSEY
Los Angeles, Calif.

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## CONTENTS NOTED

interface roughness does not completely account for adherence. Though observations made in the present study can be explained by the galvanic corrosion theory, further work is necessary to discover the other active mechanisms involved in adherence of the coatings.

### Selecting Materials for Control Valves

The materials problems involved in design and application of control valves are considerably more complex than those related to ordinary pipe fittings. Satisfactory commercial materials are not yet available for the most severe service conditions. Thus the engineer (and the user) must realize that control valves are expendable.

In a paper delivered before the Diamond Jubilee Annual Meeting of The American Society of Mechanical Engineers in Chicago last November, H. H. Gorrie of Bailey Meter and W. L. Gantz of American Viscose outlined the practical limitations of current materials used in control valves. They listed the materials most commonly used for each component, service conditions encountered by various parts, and limitations of the materials available for design.

The overall control valve assembly was considered in separate components:

**Valve body and bonnet**—Valve body and bonnet constitute the enclosure confining the fluid and containing the valve mechanism. Major considerations in their design are: 1) mechanical strength to resist internal working pressures, 2) rigidity to maintain the alignment of parts when the body is subjected to pipe-line strains, and 3) resistance to corrosion.

For valve-body and bonnet components ASTM specifications call for bronze, cast iron, carbon steel, and alloy steels such as 1.25 Cr-0.5% Mo, 2.25 Cr-1.0% Mo, 5.0

*Phenolic molded device makes flashlight*

# Safe in explosive atmospheres

Safety is achieved by use of a spring-loaded contact within the reflector assembly so designed that if the bulb of the lamp is broken, the electrical circuit will be instantly opened before the filament can ignite inflammable or explosive mixture of gas in the surrounding atmosphere.

The intricate working parts of the reflector assembly are molded of BAKELITE Brand Phenolic Plastic BMG 5000 Black. Their positive, unhampered action demonstrates the dimensional stability and strength of this material. In production, the reflector unit with its mounts and guides, exterior threads, and slots for the wire guard are formed in one operation with a 9-cavity compression mold. The retainer ring that holds the wire guard is produced in a 12-cavity high-speed plunger mold.

For further information on a wide range of phenolic plastics, write Dept. OP-108.

Reflector assembly parts made of BAKELITE Phenolic Plastic by **Auburn Button Works, Inc.**, Auburn, N. Y., for "Eveready" Safety Type Flashlight, produced by National Carbon Co., A Division of Union Carbide and Carbon Corporation, N. Y. 17, N. Y.

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## CONTENTS NOTED

Cr-0.5% Mo or 9.0 Cr-1.0% Mo. The American Standard Code for Pressure Piping limits the use of bronze to 500 F max and cast iron to 450 F max (300 F for oil). Rules for construction of power boilers in the ASME Boiler Code place service limitations of 500 F max on bronze and 250 psi max and 450 F max on cast iron.

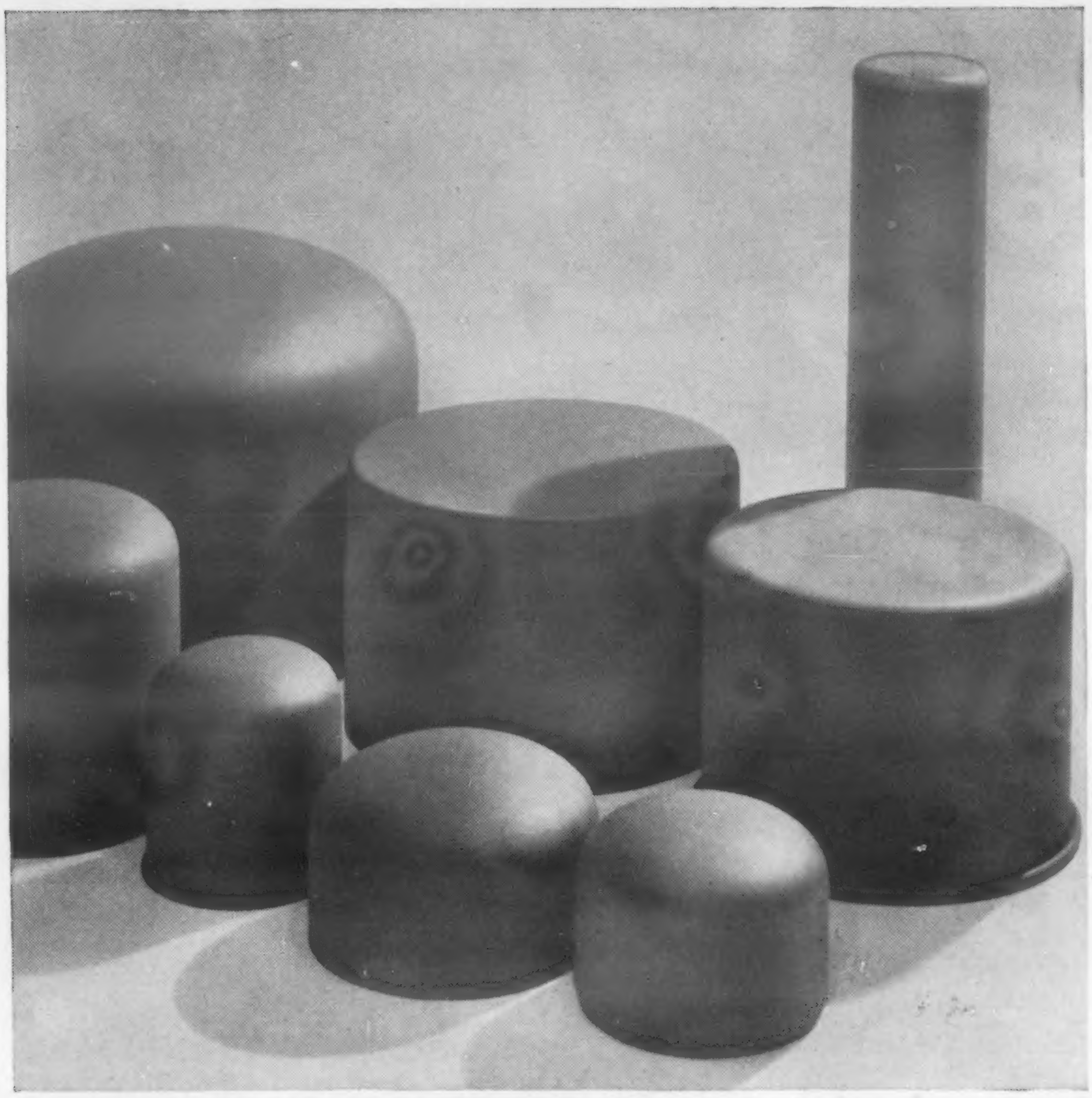
The possibility of graphite formation should be considered in carbon steels above 775 F, in carbon-molybdenum steels above 875 F, and in chrome-molybdenum steels (with chromium under 0.6%) above 975 F. Excessive oxidation or scaling is possible with the following steels at temperatures above 1050 F: 1.0 Cr-0.5% Mo, 1.25 C-0.5% Mo, 2.0 Cr-0.5% Mo, 2.25 Cr-1.0% Mo and 3.0 Cr-1.0%. At temperatures above 1100 F oxidation or scaling is possible in 5.0 Cr-0.5% Mo alloy.

**Bolting**—Bolts in flanged body-bonnet joints must resist hydrostatic end forces exerted by internal working pressure under maximum operating conditions. They must also maintain sufficient compression load on the gasket to prevent leakage.

Carbon-steel bolting is satisfactory for low temperatures, but lacks creep resistance necessary for high temperatures. High-strength alloy steel studs with high physical properties at normal temperatures and good creep properties at high temperatures are used to overcome relaxation in high-temperature service.

**Packing**—Valve manufacturers' standard packings in general consist of molded rings of asbestos fiber with plastics or synthetic rubber binder, graphite- or mica-lubricated, and various forms of Teflon. Materials using plastics or synthetic rubber binders, and Teflon are usually limited to fluid temperatures from 0 to 450 F. Graphite- or mica-lubricated asbestos materials are used generally for temperatures of 450 to 750 F.

**Valve trim** — Valve plugs, seat





## CONTENTS NOTED

rings and guide bushings require resistance to both corrosion and the eroding action of the flowing fluid. Most commonly used materials are bronze, series 400 hardening-type stainless steels, series 300 austenitic stainless steels, and monel. Other valve trim materials are nitrided stainless steels and hard chromium-plated stainless steels. There is no commercially available material that will stand up for more than a relatively short period of time under continuous fluid pressure-drops of 1500 to 2000 psi. For high-pressure drops with gas, sintered carbides have been used successfully.

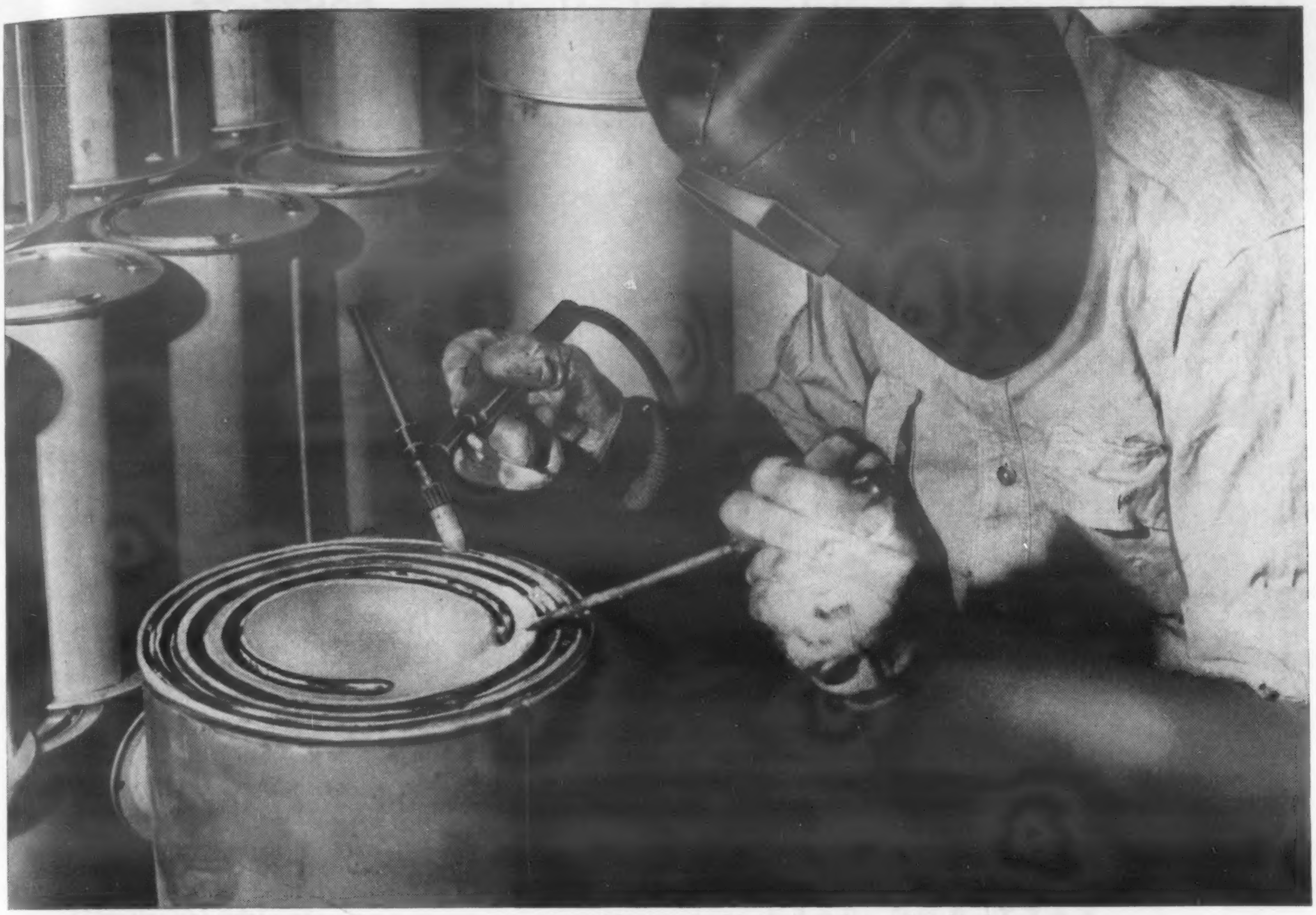
The authors also asserted that radiograph and magnetic-particle inspections of valve bodies are not warranted unless service conditions are extremely severe. Pressure tests specified in ASA B16.5-1953 will show up most flaws present in body castings.

### Friction Data on Some Plastics

Teflon and several filled Teflons were found to have exceptionally low and nearly equivalent coefficients of friction in a study made of the frictional characteristics of 17 plastics. W. C. Milz and L. B. Sargent, Jr., of the Aluminum Co. of America, reported the results of their work in a paper presented at the 10th Annual Meeting of the American Society of Lubricating Engineers.

The authors found that some of the filled Teflons performed as well lubricated with water as with oil. Of the other plastics tested, polystyrene had "dry" friction values at high speed equal to those of Teflon-type plastics, and polyethylene's coefficients of friction were as low as Teflon's when oil lubrication was used. Comparatively low friction values were also obtained for cellulose acetate and cellulose acetate butyrate with water lubrication at high speed.

Friction coefficients usually de-



## CONTENTS NOTED

creased as the applied load increased. The most likely explanation for this effect involves elastic deformation at light loads and plastic deformation at high loads.

Increased speed, especially under dry conditions, resulted in either a drop in friction or an initial rise and then a drop. For this phenomenon, the authors offered a theoretical explanation which involves the combined effects of stick-slip and shearing at low speeds, and the effect of shearing only at high speeds.

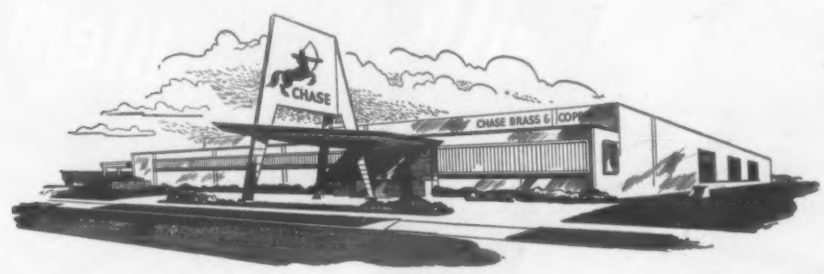
For the majority of the plastics tested friction values were found to drop as lubrication was changed from dry to water to oil. Exceptions were Kel-F and methacrylate whose friction values were unchanged by switching from dry to water lubrication, and cellulose acetate which retained identical friction coefficients at high speeds when either water or oil lubrica-

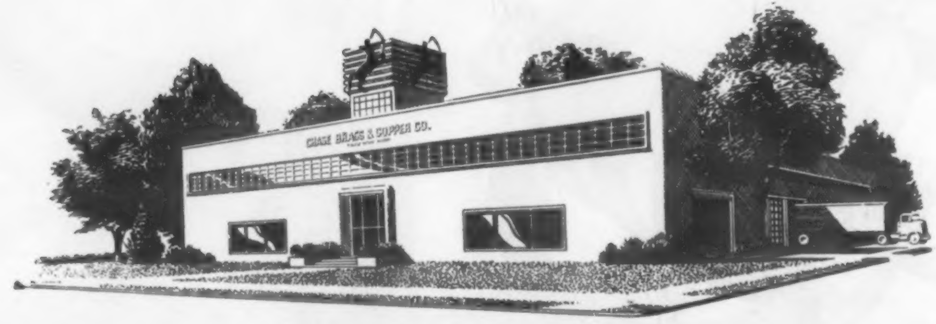
**FRICTION COEFFICIENTS**

(Applied loads: 1-5 lb.
Sliding speeds: 8-367 ft per min.)

| Plastic | Dry | Oil |
|---|---|---|
| Teflon | 0.09—0.21 | 0.04—0.06 |
| Rulon | 0.12—0.19 | 0.04—0.06 |
| Teflon-$MoS_2$, 1:1 | 0.13—0.21 | 0.04—0.06 |
| Teflon-$MoS_2$, 3:1 | 0.13—0.22 | 0.05—0.06 |
| Teflon-Graphite, 1:1 | 0.12—0.19 | 0.05—0.07 |
| Teflon-Graphite, 3:1 | 0.12—0.19 | 0.04—0.06 |
| Teflon-Asbestos, 3:1 | 0.14—0.21 | 0.04—0.05 |
| Teflon-Copper, 1:1 | 0.13—0.20 | 0.04—0.07 |
| Cellulose acetate | 0.18—0.53 | 0.08—0.16 |
| Cellulose acetate butyrate | 0.17—0.32 | 0.07—0.14 |
| Ethyl Cellulose | 0.22—0.57 | 0.07—0.16 |
| Kel-F | 0.17—0.25 | 0.08—0.15 |
| Methacrylate | 0.16—0.47 | 0.10—0.19 |
| Nylatron G | 0.22—0.33 | 0.08—0.13 |
| Nylon | 0.15—0.33 | 0.09—0.14 |
| Polyethylene | 0.17—0.40 | 0.04—0.09 |
| Polystyrene | 0.12—0.45 | 0.06—0.13 |

# CHASE ® IS THE PLACE


*Illustrated above:* **Just three of the 25 efficient Chase warehouses dotting the nation.**

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## CONTENTS NOTED

tion was used.

The addition of an "oiliness agent" such as butyl stearate to the test oil made little or no difference in the frictional characteristics of the plastics.

Plastics were run against a 1% carbon tool steel cylinder, using applied loads of 1, 3 and 5 lb. Test speeds were set at 8, 16, 52, 115 and 367 SFM with dry, water, oil, and oil plus 5% butyl stearate lubrication.

## Impervious Graphite for Corrosion Protection

Graphite can be made impervious by impregnating it with a synthetic resin, such as a phenolic or an epoxy. The resulting composite has a number of advantages as an engineering material for construction of corrosion-resistant chemical equipment. Its major limitation is its only moderate tensile strength, but this limitation can be overcome by proper design.

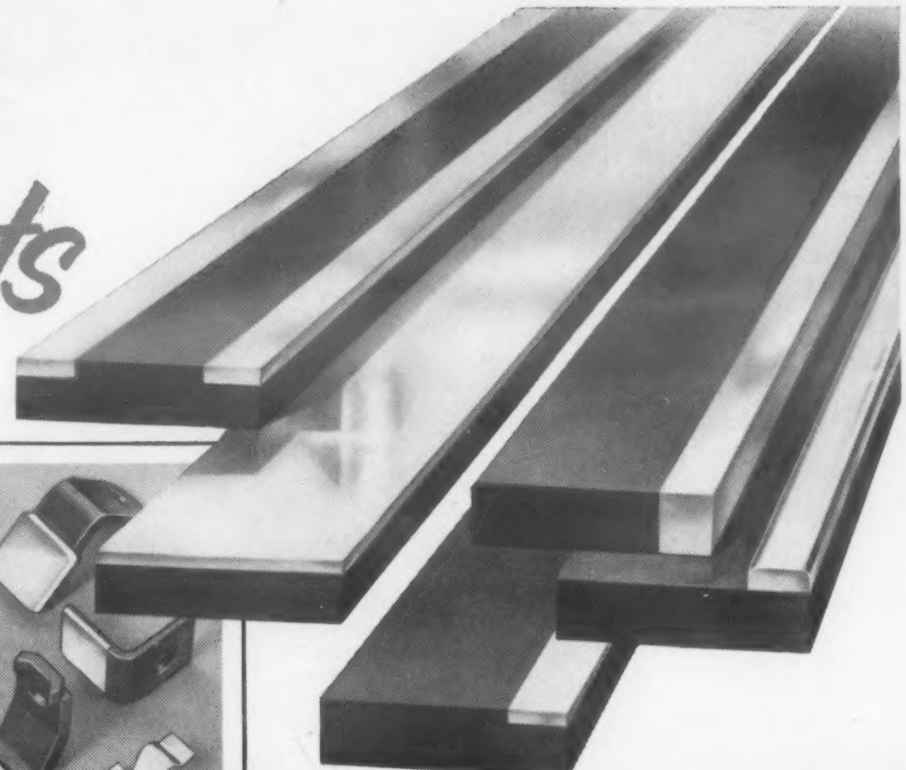
Physical and mechanical properties, applications and methods of manufacture of such a material were described by W. W. Palmquist, of National Carbon, and T. C. Martin, of Carbide and Carbon Chemicals, Divs. of Union Carbide and Carbon Corp., in a paper delivered before the 12th Annual Conference of the National Association of Corrosion Engineers last month.

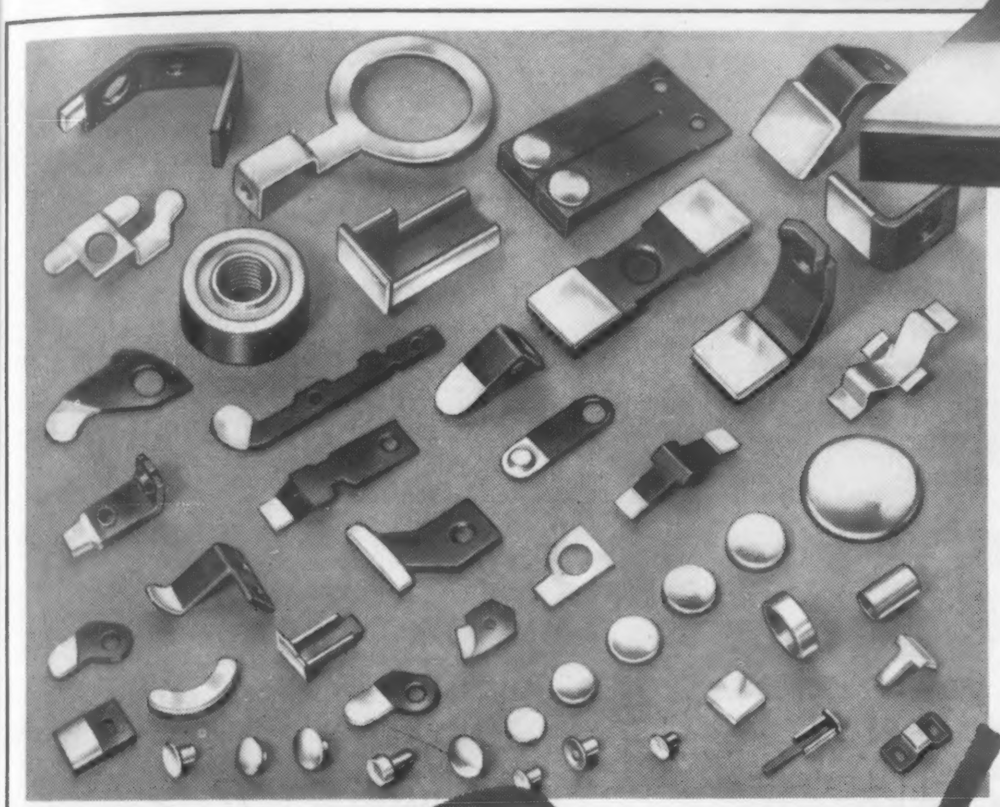
### Properties

In general, the material is light in weight and has good resistance to thermal shock and thermal deformation. It also has good electrical conductivity and good machinability. Though the temperature limit of unimpregnated graphite in non-oxidizing environments is approximately 6500 F, the generally accepted body temperature limit for resin-impregnated graphite is about 340 F.

Resistance of the material to various chemicals can be altered by changing the impregnating resin. For example, where higher

# Speaking of Cutting Costs





# General Plate

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That's right — time and time again General Plate Division has been able to cut electrical contact costs for customers — while improving product performance.

At General Plate Division customers with contact questions deal directly with a top notch team of Engineers, Production people, and Cost Analysts who specialize in contact activities.

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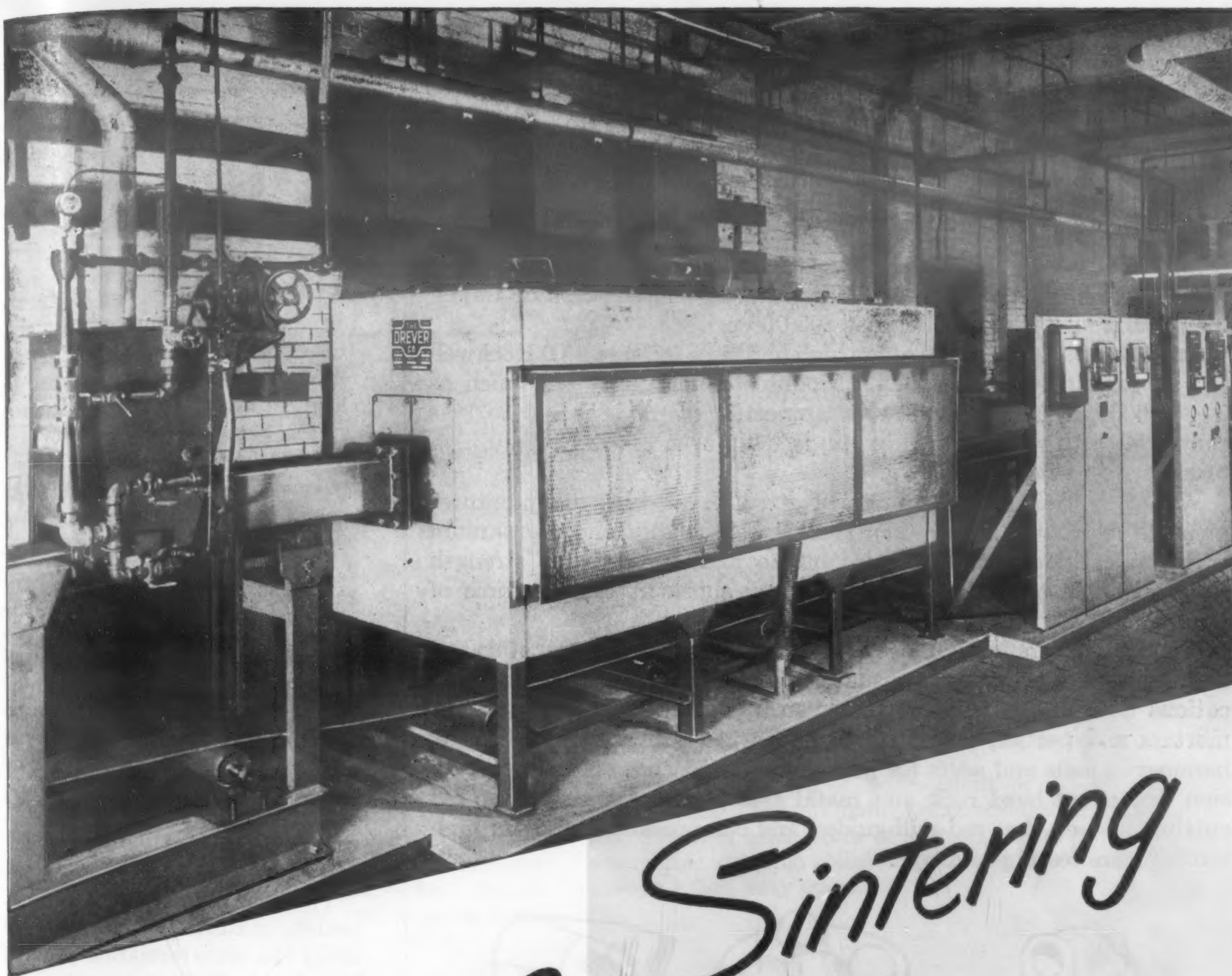
concentrations of alkaline solutions are prevalent, a modified phenolic- or epoxy-impregnated material is preferable to the conventional phenolic-impregnated graphite. Though impregnated graphite is suitable for use in a wide variety of chemicals, it is not recommended for use in hydrofluoric acid over 60%, nitric acid over 20%, sulfuric acid over 96%, bromine, iodine or fluorine.

The material has a density approximately that of magnesium. It is considerably stronger in compression than in tension. Impervious graphite is neither malleable nor ductile; however, it bends easily as indicated by its low elastic modulus. Thermal conductivity is approximately two to three times that of steel and eight to ten times that of stainless steel. The combination of good thermal conductivity and a very low coefficient of thermal expansion accounts for the material's excellent resistance to thermal shock.

**Applications**

Principal use for impervious graphite has been in heat exchangers for corrosive fluids, where its unusual combination of high thermal conductivity, chemical inertness and resistance to thermal shock is important. A number of early installations were in cascade cooler types of heat exchangers. Present-day design of these coolers is such that the impervious graphite is under compression loading only, thus avoiding difficulties due to the relatively low tensile strength.

In one specific plant, the authors reported, shell and tube heat exchangers of impervious graphite are used to boil 30 to 50% sulfuric acid at atmospheric pressure with 50 psig steam, and to boil sulfuric acid of up to 70% concentration under reduced pressures. Compared with previous use of metallic coil installations, use of impervious graphite has resulted in a reduction of plant space and, because of the material's considerably higher heat transfer coefficient, an increase of approximately 300% in capacity.



## CONTENTS NOTED

### Porcelain Enamels for Zirconium

Zirconium is receiving much attention these days as an engineering material for nuclear reactors. However, it has poor oxidation resistance and poor resistance to chemical attack by certain molten metals being considered for reactor coolants.

A notable step in combatting these limitations was recently reported in a paper presented to the American Institute of Chemical Engineers by J. Schultz, H. P. Tripp, B. W. King and W. H. Duckworth of Battelle Memorial Institute. Proceeding on the theory that a coating of glass on zirconium could protect the metal from oxidation or from attack by liquid metals, these investigators developed several porcelain enamels for zirconium.

**Effectiveness**

The enamels developed for zirconium matured either below or above the transformation point of the metal. They were adherent, free of crazes and other defects, and had low thermal-neutron-absorption cross sections. Frit compositions were based on the lead oxide-silica system.

The enamels successfully protected the metal from oxidation when tested in air for 1000 hr at 1112 F. They also afforded protection from liquid lead at 650 F and liquid bismuth at 1112 F for 100 hr. They were rapidly attacked by potassium at 650 F. The enamels did not appear suitable for protecting zirconium against high temperature water.

**Composition**

In none of the enamels maturing below the transformation point of zirconium was it possible to add more than about 10% by weight of any oxide or combination of oxides to a lead silicate glass and produce a satisfactory coating. On the other hand, the range of suitable compositions of enamels for zirconium maturing above the transformation point was very wide. Satisfactory enam-

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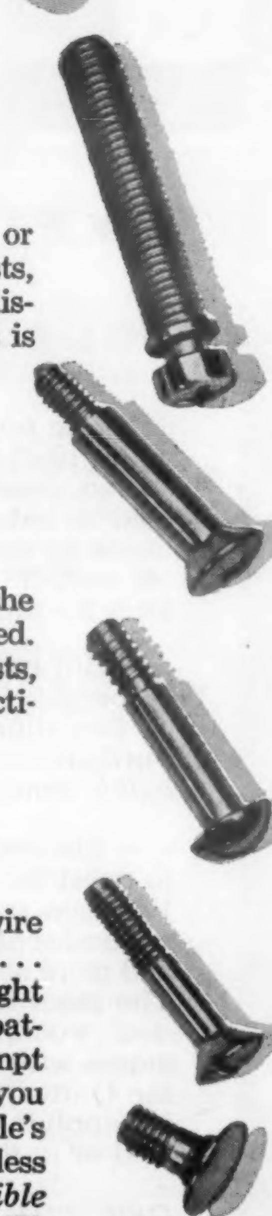
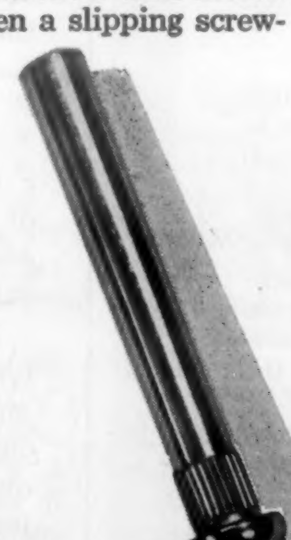
## ✓ for boosting product quality!

Where appearance and performance call for quality parts, don't overlook the advantages of stainless steel fasteners. Take the illustrated E. W. Ferry fasteners, for example. They're priced right in line with quality fasteners of other materials. Yet they offer all the extra qualities stainless steel brings to any part — high tensile strength . . . attractive, rust-resisting finish . . . and remarkable resistance to heat and corrosion. In almost any application they outlast, many times over, fasteners of nonresistant or plated metal. They cut maintenance costs, too. For even after years of service, disassembling rust-free stainless fasteners is always a fast, easy operation.



## ✓ for reducing production costs!

The hardness of stainless steel fasteners results in substantial savings on the assembly line. Work is faster, results are better — simply because stainless screw-heads are less apt to burr and nick. This means major savings, for even a slipping screwdriver can seriously damage both the screw and the parts being assembled. Stainless steel fasteners cut tooling costs, too. For they are now available in practically every size and description.



Crucible now offers stainless fastener wire in all diameters . . . in suitable tempers . . . in a variety of finishes, including bright and several metallic and nonmetallic coatings . . . in all standard grades. For prompt delivery of the stainless steel wire you need — or for your free copy of Crucible's new, 32-page catalog "Rezistal Stainless Steel Wire" — call or write to *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

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## CONTENTS NOTED

els were developed with lead oxide contents ranging from 64 to 22% by weight.

In general, as the lead oxide content decreased, the refractoriness increased. Complete elimination of lead oxide, with the silica content maintained at nearly its original level, resulted in a very refractory enamel which matured above 2100 F.

The majority of the work was done on crystal bar zirconium. To eliminate the tendency of rolled zirconium to cause crazing of the enamels because of non-uniform contraction on cooling, the metal was heat treated for ½ hr at 1740-2000 F in gettered argon.

### Thermoplastics Pipe Resists Corrosion

The combination of chemical resistance and toughness of some thermoplastic resins makes them highly useful as pipe materials in industries where corrosion is a problem. Thermoplastic pipe materials widely used by industry today are polyethylene, polyvinylidene chloride, cellulose acetate butyrate, styrene-acrylonitrile copolymers, and vinyl chloride polymers (rigid PVC).

In a paper delivered last month at the 12th Annual Conference of the National Association of Corrosion Engineers, J. F. Malone, of B. F. Goodrich Chemical Co., and J. S. McBride, of Owens-Corning Fiberglas, described the properties of these materials in some detail and pointed out their major application in present-day industry.

*Polyethylene* accounts for the largest portion of thermoplastic materials currently sold for industrial use, according to the authors. Since polyethylene pipe is inexpensive, can be coiled and is easily coupled, its major use has been in water systems, particularly jet wells. Use of such pipe is restricted by low operating temperatures and pressure. One company has used polyethylene to replace steel in lines carrying acids, alkalies, salts and water.

## CONTENTS NOTED

Operating pressures have been low, with temperatures ranging from 60 to 100 F. Much of the pipe is buried. Over four years of service it has given completely satisfactory service.

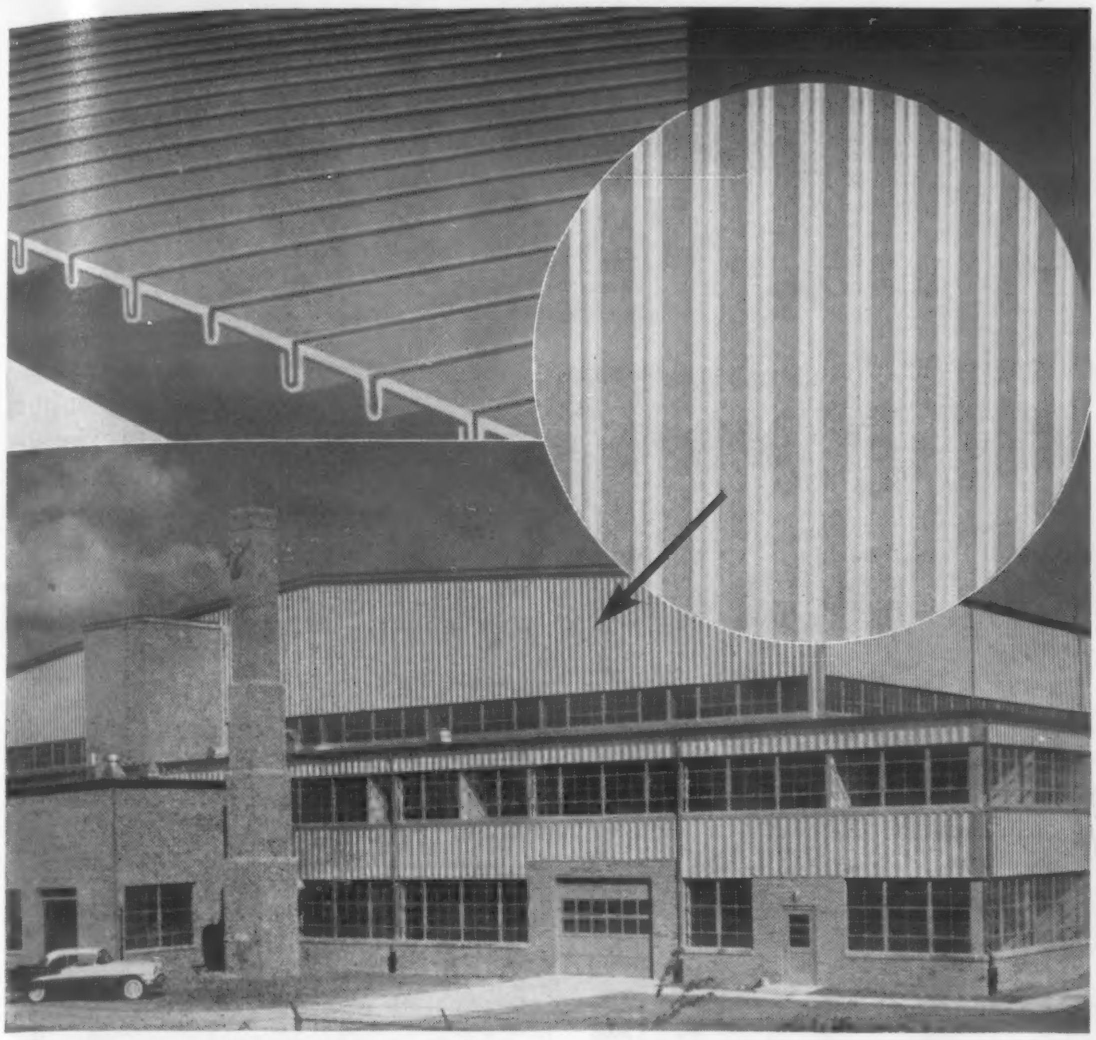
*Vinylidene chloride* (Saran) is being used primarily in linings, since it has a high degree of resistance to salts, acids and alkalies.

One company uses the material both as a lining and as a structural material; in one application vinylidene chloride pipe is supported every 10 ft, while in another case it is supported continuously in a channel. The pipe carries an acid of 37% concentration and is subjected externally to solvent vapors. Temperatures range from 32 to 90 F and pressures are under 50 psi. This particular installation has been in operation for more than three years and indications are that it will provide at least five more years of satisfactory service.

*Butyrate* has been widely used, particularly in the oil industry, since it has good chemical resistance and can be easily coupled. In most successful applications the pipe has been buried. One oil company has installed almost five miles of 4-in. pipe for transmitting sour crude under 50 psi pressure at temperatures from 32 to 120 F. After 2½ years service the pipe has proven to be satisfactory, and there has been no paraffin build-up.

*Styrene-acrylonitrile* copolymers are used for the same type of applications as butyrate. They have a certain advantage in that they retain their toughness at low temperatures. One chemical plant reports over three years of satisfactory service carrying salt water, both on the surface and buried, under conditions of 125 F maximum temperature and 80 psi maximum pressure. Inspection indicates a minimum service life of five years.

*Rigid PVC* may have the greatest potential of any thermoplastic in the industrial field, particularly as pipe. It has high impact

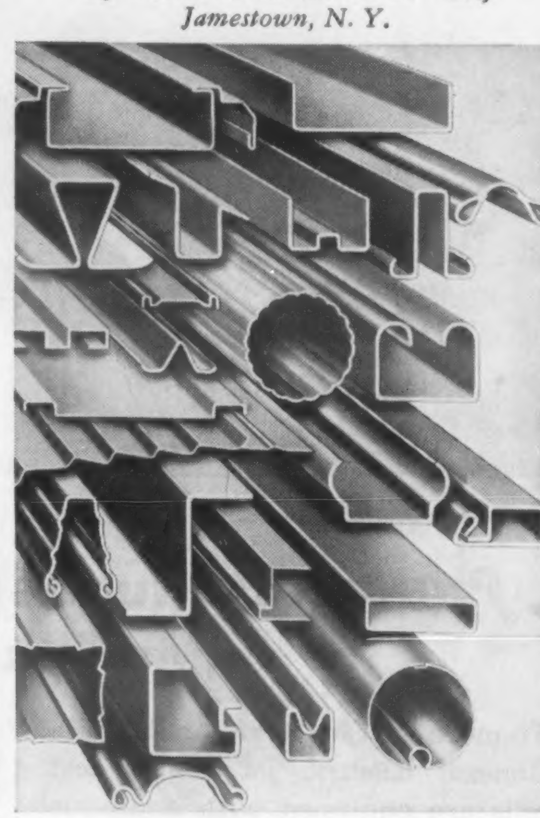


(TOP) *Cross-section of cold-roll-formed Roof Deck by Walker Supply & Mfg. Co., Ecorse, Michigan.*

(INSET CIRCLE) *Aluminum siding panels, (made by Walker Supply & Mfg. Co.) give fine architectural effect.*

*Elevator Door, Casing and Trim, by Dahlstrom Metallic Door Co., Jamestown, N. Y.*

# 1001 things being done by COLD ROLL FORMING



The Cold-Roll Forming Machine is a powerful weapon in the hands of mass-production metal-working industries striving to fight inflationary forces with technological advances.

This applies even to the building industry, long considered immune to mass-production methods. The field abounds in opportunities for cost reduction through cold-roll forming of components for quick and easy assembly and erection on the job. The list includes, for example, specially designed wall, partition, floor and roof systems, nailable studs and joists, cabinets, closets, windows, doors and trim. It even includes exterior coverings, for architectural beauty as well as insulation and weather protection (see photo above).

The Yoder Book on Cold-Roll Forming contains numerous illustrations with information on the economic and mechanical possibilities of cold-roll forming, the machines and the tooling. Yoder has long been looked up to as the leader in designing and building all such equipment. A copy of the book is yours for the asking.

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## CONTENTS NOTED

strength, a wide temperature range of service, and good weathering properties. One interesting application has been use of the material to replace steel in an electrical conduit. The conduit operates in the presence of sulfur dioxide fumes. Steel previously used failed in several months, whereas rigid PVC conduit has been in service for three years.

### Titanium Fatigue vs Surface Finish

Recent evidence indicates that surface finishing has a pronounced effect on the fatigue strength of titanium alloys. In order to determine the correlation between surface hardness and fatigue of titanium, an investigation was carried out at the University of Illinois on titanium alloys RC 130B and Ti 140A. The types of finishes studied included rough-machined, machined and mechanically polished, cold rolled, electropolished and ground.

Results of the investigation were given by G. M. Sinclair, H. T. Corten and T. J. Dolan, of the University, in a paper delivered at the Diamond Jubilee Annual Meeting of the American Society of Mechanical Engineers last December.

#### Correlations

In general, a correlation was found to exist between indentation hardness of the metal surface and its fatigue strength. Roughness influences fatigue strength, but the effect does not appear to be as important as that of hardness in the surface layer. Such operations as rough machining, surface cold rolling, and grinding introduce different degrees and different depths of cold work and residual stress in surface layers of

#### CORRECTION

In the article "Modified Woods—Old and New" published in March, an error was made in labeling the lefthand graph on p 110. The label on this chart should have read "Change in length" rather than "Change in width".

**For more information, turn to Reader Service Card, Circle No. 362**

## CONTENTS NOTED

metal which strongly influence its resistance to fatigue. Indentation hardness readings reflect the degree of cold work and, to a lesser extent, the residual stress present. Cold rolling produced the highest hardness in the surface layer while grinding gave the lowest value; in one case the ground surface appeared to be slightly softer than the core metal.

The authors found that the effect of machining and finishing operations on fatigue strength was due to the formation of a disturbed metal layer on the surface of RC 130B and Ti 140A alloys. The disturbed layer may extend from 12 to 15 thousandths of an inch below the surface in the case of simple machining.

**The equation**

As a first approximation, the authors found that the relationship between fatigue limit, roughness and surface hardness for their data can be expresed as:

$$Z = 207\ X^{-0.0284}\ Y^{1.017}$$

Where

$Z$ = fatigue limit, psi

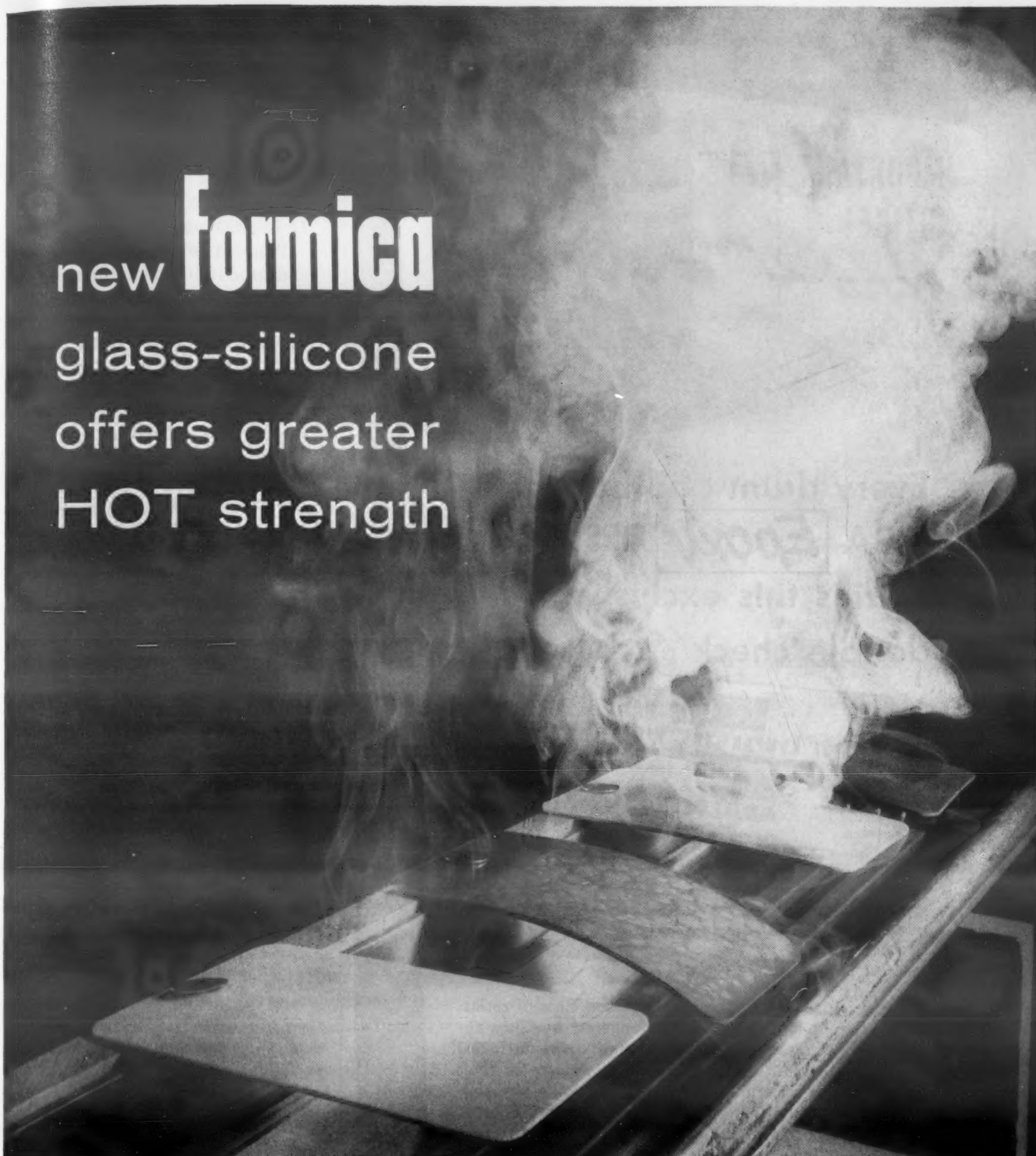
$X$ = rms surface roughness, microin.

$Y$ = Knoop surface hardness, (100 gm load)

The authors interpret this equation as indicating that surface roughness does not seriously influence fatigue strength of these two titanium alloys. The fatigue limit falls off gradually and at a decreasing rate with increasing roughness. For constant values of surface roughness, the relationship between fatigue limit and surface hardness is approximately linear, as in the case of steels. It was also found that a given change in surface roughness lowers the mean value of fatigue limit more at high hardnesses than at low hardneses.

**BOOKS**

**Handbook of Fastening and Joining of Metal Parts.** *Vallory H. Laughner and Augustus D. Hargan. McGraw-Hill Book Co., New*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offers greater
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## CONTENTS NOTED

### BOOKS

*York 36, N.Y. 1956. Cloth 8½ by 11 in., 622 pp. Price $15.00.*

Planned to help both designers and production men, the book covers accepted practice in assembling or fastening metal parts. Screw threads and nuts, collars, couplings, keys, brazing, soldering and welding are discussed.

Such factors as joining of dissimilar metal, types of resins and adhesives used to fasten metal to metal or to other materials, and the advantages and disadvantages of different types of joints are considered. A 200-page section is devoted to techniques for solving special problems in fastening and joining.

**The Economic Almanac.** *Thomas Y. Crowell Co., New York 16, N.Y. 1956. Cloth 5½ by 8½ in., 688 pp. Price $3.95.*

This is the 13th edition of the National Industrial Conference Board's handbook of statistical and related data useful to business executives, engineers and others interested in current economic data. The book is divided into 25 sections ranging across the economic field.

Of particular interest to the engineer are the sections dealing with natural resources, manufacturing and the statistics of individual industries. Among industries covered are iron and steel, copper, aluminum, nickel, magnesium and rubber.

**Steels for the User.** *R. T. Rolfe. Philosophical Library, New York, N.Y. 1956. Cloth 6 by 9 in., 399 pp. Price $10.00.*

This book is an attempt to bridge the gap between science and practice for carbon steels in industry. The book is practical but ample explanation is given to enable the reader to understand what is occurring. Twelve chapters discuss such factors as mechanical quality, requirements for commercial steels, effects of composition, heat treatment, use of steels at elevated temperatures,


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*Teflon is Du Pont's registered trademark for its tetrafluoroethylene resin

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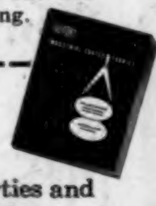

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## CONTENTS NOTED

### BOOKS

fatigue testing, weld testing and principles of selection.

**Zinc and Light Metal Die-Casting.** *Organization for European Economic Co-operation, Washington 6, D.C. 1955. Paper 6 by 9½ in., 149 pp. Price $2.00.*

This report covers the observations of a team of Europeans who visited the United States under the auspices of the O.E.E.C. They visited 50 foundries, finishing plants, machine makers, alloy producers and research organizations, of which about 30 were die casters. The report discusses die casting machines, die design, metallurgy, foundry practice and finishing.

**Technical Papers.** 12th Annual National Technical Conference. *Society of Plastics Engineers, Inc. Greenwich, Conn. 1956. Paper 5½ by 8½ in., 618 pp. Price $7.50.*

This volume contains 56 of the papers presented at the January 1956 meeting of the Society. Subjects covered are injection molding, epoxy resins, properties, molding and extrusion, thermoplastics sheet, extrusion, coating, reinforcement, foams, plastic pipe, reinforced plastics and design.

**Plastics Progress 1955.** *Edited by Phillip Morgan. Philosophical Library, New York, N.Y. 1956. Cloth 6 by 9 in., 432 pp. Price $17.50.*

This volume contains the papers and discussions given at the British Plastics Convention in 1955. Included are papers on polymer structure and properties, expanded plastics, thermoplastics, extrusion, injection molding, foundry resins and glass reinforced plastics. Many of the papers cover original investigations which are appearing in print for the first time. A complete record of the discussions is included.

**Minerals Yearbook Area Reports—Volume III, 1952.** *U.S. Government Printing Office. 1955. Cloth 6 by 9 in., 1050 pp. Price $3.75.*

This is the final volume of the 1952 Yearbook published by the

## CONTENTS NOTED

### BOOKS

Bureau of Mines. It contains chapters covering each of the 48 states, plus chapters on Alaska, Territories and Island possessions in the Pacific, and the Caribbean including the Canal Zone. A chapter summarizing the statistics on a regional basis is included also.

**The Machinist Dictionary.** *Fred H. Colvin. Simmons-Boardman Co., New York, N.Y. 1956. Cloth 6 by 9 in., 496 pp. Price $7.50.*

This book presents definitions of machine terms, parts, industrial materials and standards of industrial interest. Tables, sketches and graphs are used to give additional information if necessary to cover the pertinent facts. Trade names are included to enable the designer or engineer to determine the approximate composition of proprietary products.

**The Arc Welding of Aluminum.** *Aluminum Development Association, London W.1, England. 1955. Paper 6 by 9 in., 92 pp. Price $.35.*

This is a practical book dealing with the electric arc welding processes applicable to aluminum. It includes chapters on the welding arc, characteristics of aluminum in relation to arc welding, weldability of wrought and cast alloys, inert gas shielded arc welding processes, metal-arc welding, carbon-arc welding and atomic hydrogen welding. Included also are brief comments on safety, economics, design and testing.

### REPORTS

**Molybdenum stress-strain** Tensile deformation of molybdenum as a function of temperature and strain rate. *R. P. Carreker, Jr., and R. W. Guard. General Electric Co. Research Laboratory. Jan 1955. 31 pp, photos, drawings, graphs, table. Available from Office of Technical Services Dept. of Commerce, Wash. 25, D.C. $1. (PB 111815)*

True stress-strain data are reported for nominally pure molybdenum (99.95%) over the temperature range from —320 to 2800 F. Strain-rate sensitivity was determined. In-


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## CONTENTS NOTED

### REPORTS

homogeneous yielding and strain-aging effects were observed.

**Titanium carbide** *Titanium Carbide Base Cermets. T. S. Shevlin and C. C. McBride. Ohio State Univ. Research Foundation. Jan 1950. 28 pp, photos, drawing, tables. Available from Library of Congress, Photoduplication Service Publications Board Project, Wash. 25, D.C. Mimeo $2.70, photo $4.80 (PB 118684)*

Preliminary survey of the physical properties of sintered titanium carbide alone and in combination with a number of metals and alloys especially selected, except in the case of iron, for their known or postulated ability to both wet titanium carbide and promote resistance to oxidation at high temperatures.

**Irradiated zirconium** Effect of Nuclear Radiation on the Structure of Zircon. *Heinrich D. Holland and David Gottfried. Princeton Univ. Sept 1954. 47 pp, graphs. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo $3.30, photo $7.80. (PB 118328)*

Effect on specific gravity, unit cell dimensions and optical properties. Specific gravity of zircon drops 16% and the material becomes isotropic and so disordered that it fails to yield x-ray diffraction peaks.

**Ozone-resistant rubber** Development of Ozone and/or Oxygen Resistant Polymers. *Final technical report, June 1, 1952 to Feb 28, 1954, under a government contract. R. G. Spain. Burke Research Co. Feb 1954. 105 pp, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $2.75 (PB 111722)*

**Printed circuits** Adhesive for Composite Material Used in Printed Circuitry. *Russell M. Houghton and Virgil Lorenzini. Houghton Laboratories, Inc. Under government contract.* First Quarterly Progress Report for Period Mar 15, 1953-June 15, 1953. *June 1953. 16 pp, table. Mimeo $2.40, photo $3.30. (PB 118939)* Second Quarterly Progress Report for Period June 15, 1953-Sept 14, 1953. *Sept 1953. 22 pp, tables. Mimeo $2.70, photo $4.80. (PB 118940) Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C.*

**Flex strength of plastics** Flexural Tests of Structural Plastics at Elevated Temperatures. *John E. Wier and Dorothy C. Pons. National Bureau of Standards. Jan 1954. 68 pp, graphs, tables. Available from*

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### REPORTS

*Library of Congress. Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo $3.90, photo $10.80. (PB 119102)*

Flexural strength and modulus of elasticity determined for glass-fabric laminates bonded with three types of commercially available heat resistant resins. Temperatures ranged from 300 to 700 F, and exposures ranged from 10 min to 1000 hr. Loss of weight also determined.

**Structural adhesives** Investigation and Development of High-Temperature Structural Adhesives. *H. N. Homeyer, Jr., J. H. Preston and K. L. McHugh. Connecticut Hard Rubber Co. Aug 1954. 120 pp, photos, drawing, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $3. (PB 111768)*

**Glass reinforcement** Parallel Glass Fibre Reinforcement for Plastic Laminates. *Final report on government contract. Firestone Tire & Rubber Co., Defense Research Div. Mar 1955. 32 pp, photos, diagram, tables. $1. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. (PB 111719)*

Results of experiments in using parallel glass fibers in 1) edges and corners, 2) honeycomb sandwich construction, 3) reinforced plastics tubing, and 4) body armor.

**Plastics shrinkage** Post-Molding Shrinkage Characteristics of Some Thermosetting Plastic Molding Materials. *Steven T. Marshall and Charles P. Ellis, Jr., Materials Laboratory, WADC, Wright-Patterson Air Force Base. May 1953. 29 pp, graphs, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash 25, D.C. Mimeo $2.70, photo $4.80. (PB 119042)*

Dimensional stability of commercially available melamine, phenolic and polyester plastics molding materials was investigated by means of accelerated aging procedures. Of materials tested, a polyester mineral-filled molding material demonstrated the best dimensional stability.

**Carbide binders** Binders in Cemented Refractory Alloys. *J. T. Norton, J. Gurland, P. Rautala. Dept. of Metallurgy, Inst. of Technology. June 1951. 156 pp, photos, diags, graphs, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo $7.50, photo $24.30 (PB 119136)*

An effective binder must not lead to the presence of a third phase in

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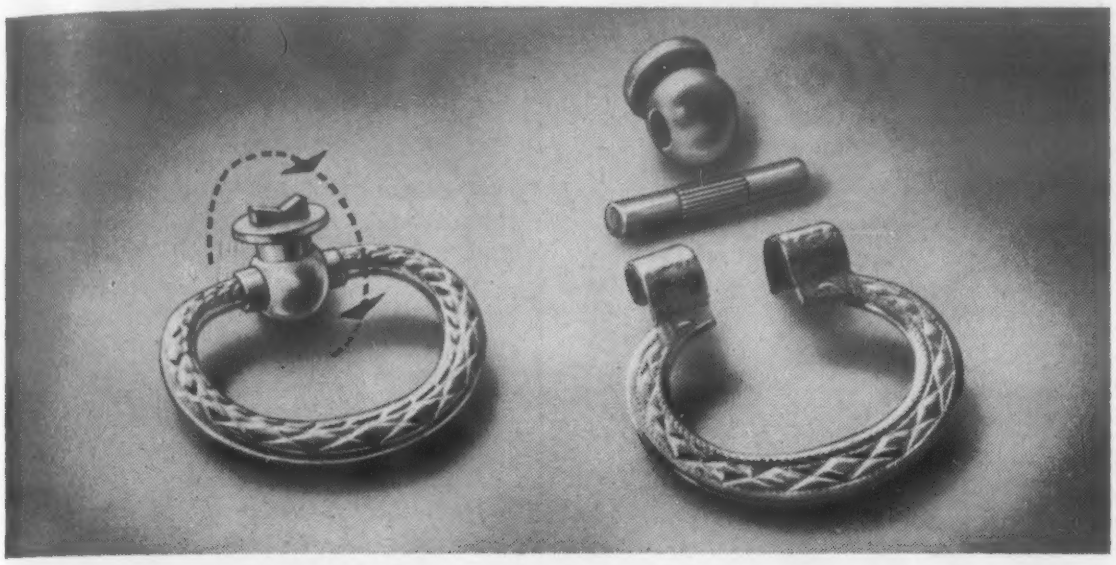

GRC "Intercast" swivel ring on left cast—assembled complete in single operation. Ring on right required assembly of two screw machine parts plus a metal stamping.

**"Intercast", exclusive Gries cast-assembly technique of die casting small zinc-alloy movable-parts affords production economies, better appearance in manufacture of picture frame rings.**

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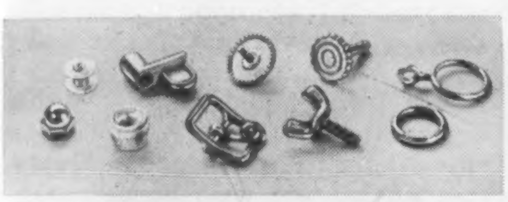

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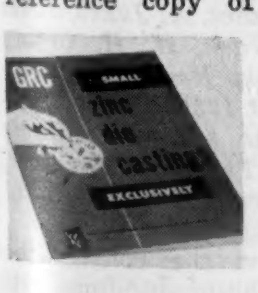
To learn how designs can be simplified and assembly operations reduced or eliminated, write for useful reference copy of Gries' fact-filled bulletin. In addition, Gries' staff is available to manufacturers for personal consultation on design and production of GRC automatically die-cast and plastic - molded small parts.



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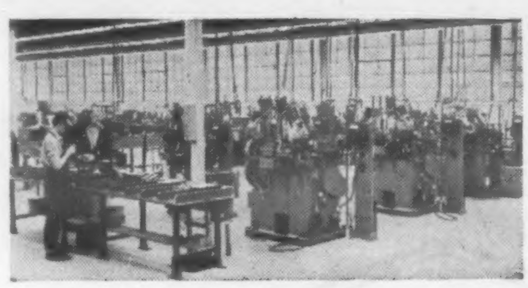

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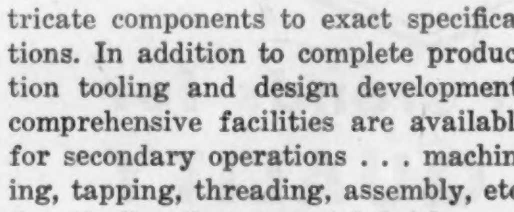

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## CONTENTS NOTED

### REPORTS

the sintered products. On that basis, cobalt and nickel are suitable as binders for wolfram (tungsten) carbide, but copper and iron are not.

**Titanium** Handbook on Titanium, Part 2. *Heinrich K. Adenstedt. Lycoming Div., Avco Manufacturing Corp. Sept 1955. 161 pp, photos, drawings, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $4.25. (PB 111873)*

Condensed information on laboratory procedures and fabrication of titanium and its alloys.

**Steel weldments** Hot Cracking of Stainless Steel Weldments. *P. P. Puzak, W. R. Apblett and W. S. Pellini. Naval Research Laboratory. Aug 1955. 19 pp, photos, diags, graphs, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo $2.40, photo $3.30. (PB 119010)*

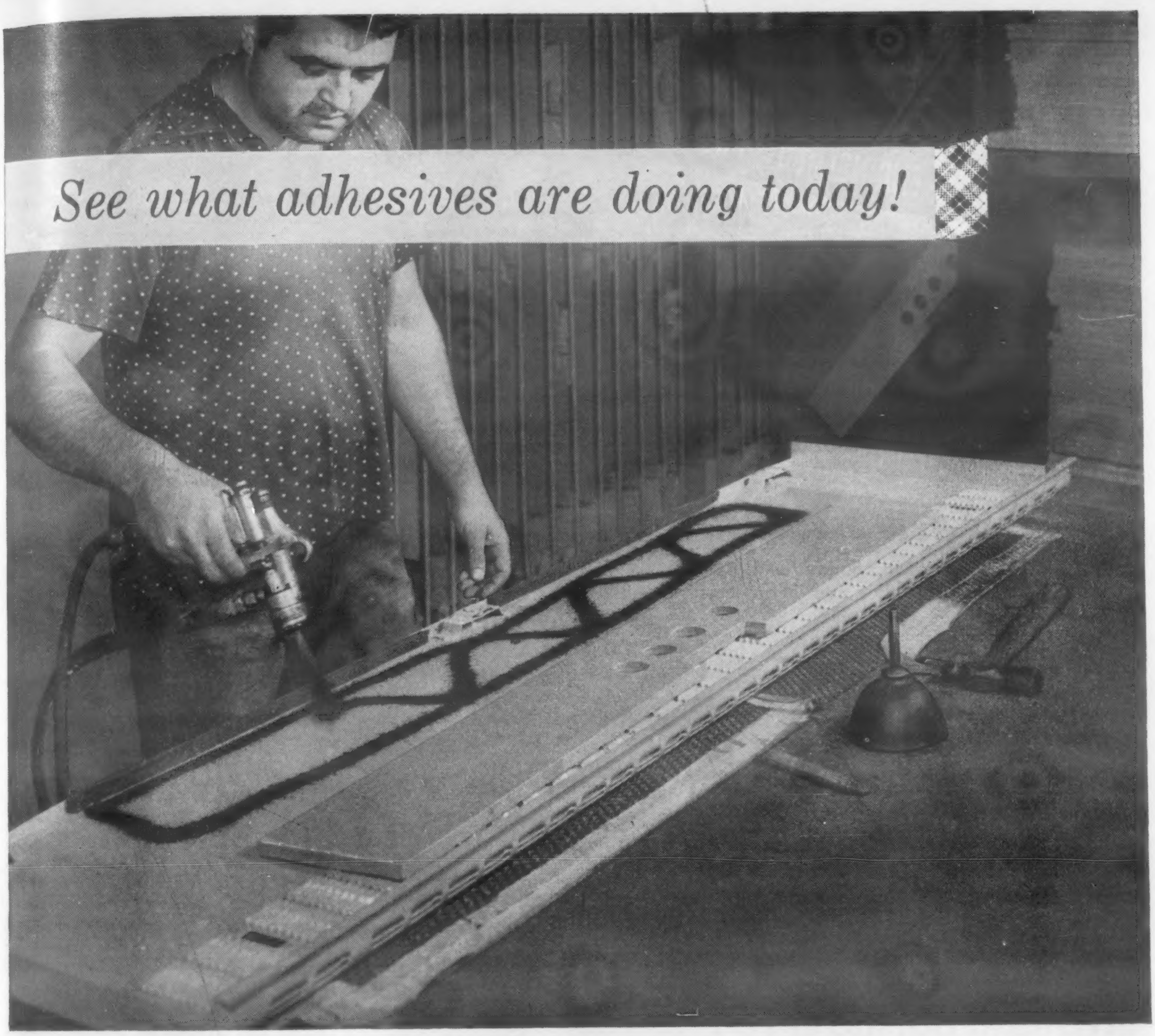
Types 347 and type 304 stainless steels were investigated. Hot cracking of the base metal was found to result from liquidation of fusible segregrates located at the boundaries of grains which adjoin the fusion line of the weld proper.

**Titanium creep** Intermediate Temperature Creep and Rupture Behavior of Titanium and Titanium-Base Alloys, *Jeremy V. Gluck and James W. Freeman. Engineering Research Inst., Univ. of Mich. Sept 1954. 114 pp, photos, graphs, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo $6, photo $18.30. (PB 119041)*

Tensile, short time rupture and creep properties obtained in order to determine relationship between typical structural conditions and mechanical properties in the 600 to 1000 F temperature range. Materials studied were: commercially pure titanium, Ti 75A; a commercial alpha-beta alloy, Ti 150A; an experimental stable alpha alloy, 6 Al-94% Ti; and an experimental stable beta alloy, 30 Mo-70% Ti. Hardness, x-ray and metallographic studies were made.

**Magnesium alloys** Magnesium Alloy Research Studies. *A. Jones, J. H. Lennon, R. R. Nash, W. H. Chang and E. G. McPeek. Rensselaer Polytechnic Inst. Sept 1952. 140 pp, photos, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $3.50. (PB 111762)*

Diagrams show the constitution of magnesium-lithium-aluminum and

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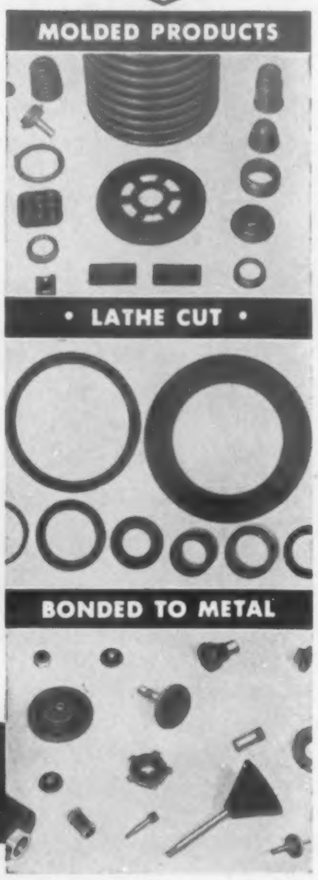







## CONTENTS NOTED

### REPORTS

magnesium-lithium-zinc alloy systems at 500 and 700 F.

**Bronze castings** Methods for Improving Soundness of Gunmetal Bronze Castings. *W. H. Johnson, H. F. Bishop and W. S. Pellini. Naval Research Laboratory. July 1955. 16 pp, photos, drawings, diags, graphs. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo $2.40, photo $3.30 (PB 119011)*

Two methods compared: vacuum treatment of melts and wedge chilling of castings.

**Silicon and germanium** Optical and Photoconductive Properties of Silicon and Germanium. *E. Burstein, G. S. Picus and N. Sclar. Naval Research Laboratory. July 1955. 46 pp, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.25 (PB 111748)*

**High temperature titanium** Titanium Alloys for Elevated Temperature Application. *W. F. Carew, F. A. Crossley and D. J. McPherson. Armour Research Foundation, Chicago, Ill. Under government contract. Available in two parts from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C.*

Part 1. *June 1955. 323 pp, photos, tables. Mimeo $11.10, photo $49.85 (PB 119008).* Effect of carbon, nitrogen and oxygen on tensile, impact and creep-rupture properties of Ti-6% Al alloy. Tensile test evaluation of experimental alloys, including binary alloys containing beta-stabilizing additions. Effect of vacuum annealing on tensile ductility of alloys containing 8% or more of aluminum. Creep-rupture and creep evaluation. Stability of room temperature tensile properties upon exposure to creep at elevated temperatures. Rolling and welding characteristics of the alloys: 6 Al-0.5% Si, 6 Al-4% V and 7 Al-3% Mo. Covers period from June 1953 to May 1954.

Part 2. *July 1955. 112 pp, photos, graphs, tables. Mimeo $6, photo $18.30 (PB 119009)* Effects of various practical alloying elements on elevated temperature properties of titanium alloys. Covers period from June 1954 to Dec 1954.

**Ceramics** Mechanical-Property Tests on Ceramic Bodies. *O. K. Salmassy, W. H. Duckworth and A. D. Schwope. Battelle Memorial Inst. Under government contract. Mar 1953. 157 pp, photos, drawings, diags, graphs, tables. Available from*


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## CONTENTS NOTED

### REPORTS

*Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Mimeo, $7.50, photo $25.80 (PB 119092)*

Object is clear understanding of the fracture of ceramic bodies and, if possible, quantitative definitions of resistance to fracture in terms of external variables. Effects of size and stress state emphasized. Effects of strain rate and temperature also considered. Most research conducted on plaster of Paris. Porcelain and nickel-bonded titanium carbide also tested. Covers period from Feb 1952 to Feb 1953.

**Prestressed ceramics** Prestressed Ceramic Structures. *F. R. Shanley, W. J. Knapp and R. A. Needham. Dept. of Engineering, Univ. of Calif. Jan 1955. 105 pp, photos, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash, 25, D.C. $2.75 (PB 111944)*

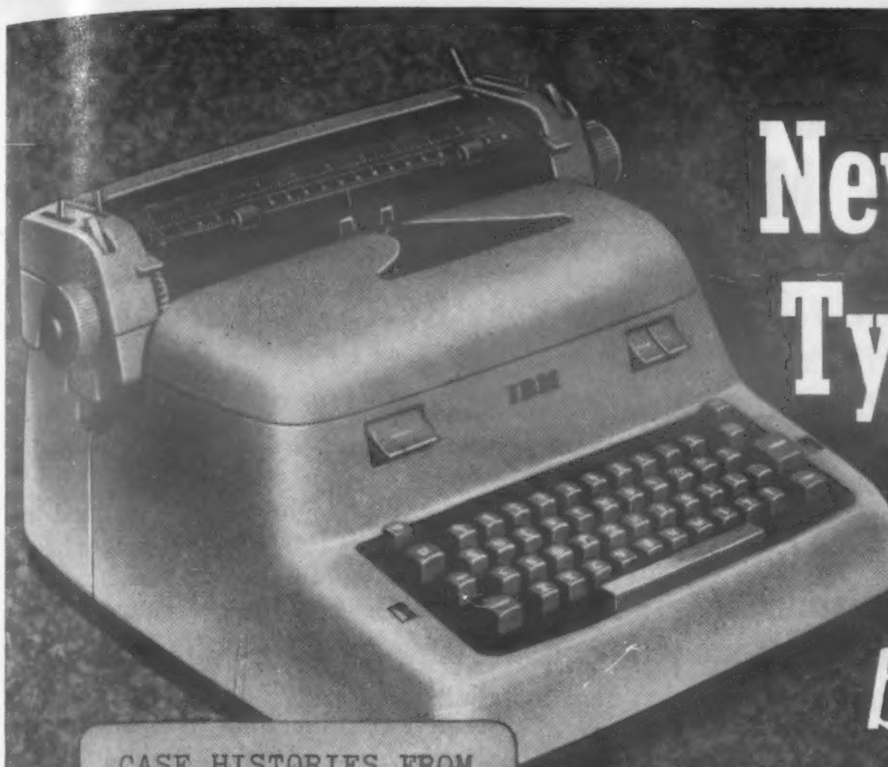
Development of an efficient structure which will withstand high temperatures appears possible through the use of prestressed ceramic structures, but further research and experimental work must be done before such construction can be incorporated into actual aircraft missiles. Recommendations for future programs included.

**Rubber diaphragms** Development and Test of Diaphragms from Synthetic Rubber Materials. *Newton J. Lumm. Bendix Products Div., Bendix Aviation Corp. Aug 1953. 74 pp, photos, diags, graphs, tables. Mimeo $4.50, photo $12.30 (PB 119090)*

Low temperature and ozone resistant convoluted type diaphragms for use in fuel metering devices.

**Hot rubber** Development of a Rubber for High Temperature Service in Contact with Experimental Hydraulic Fluids. *Frederick G. Kitts. Materials Laboratory, WADC, Wright-Patterson Air Force Base. Aug 1954. 20 pp, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 50 cents. (PB 111766)*

Proposed operation of hydraulic systems at temperatures in excess of 500 F has made necessary the development of a new rubber for packings, gaskets, hose, etc. Of various commercial and experimental polymers evaluated at elevated temperatures, ethyl acrylate copolymers were found to have the best inherent resistance to new fluids at high temperatures.



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Mr. Jerome J. Theobald
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Mr. George E. Hahl
39 South Munn Ave., East Orange, N. J.

For more information, turn to Reader Service Card, Circle No. 490

# NEWS OF ENGINEERS COMPANIES SOCIETIES

## NEWS OF ENGINEERS

**Dr. Dale E. Mancuso** has joined the Research & Development Department staff, Glendale Plaskon Laboratory, Barrett Div., Allied Chemical & Dye Corp.

**Paul E. Fleming** is senior administrative engineer in the Mechanical Engineering Dept., United States Testing Co., Inc.

**James M. Klaasse** has been appointed chief engineer, American Instrument Co., Inc.

**B. W. Bogan** has been named to the newly created post of executive engineer, Dodge Div. Mr. Bogan, who has been chief engineer since 1950, has been associated with Dodge and the parent Chrysler Corp. since 1933.

**E. Walter Hammer, Jr.**, is chief engineer, United Manufacturing Co. He was formerly chief of the Machine Design and Development Section for research and development, Franklin Institute Laboratories.

**Russell H. Lasche**, formerly assistant to the president, is now general manager, Industrial Camera Div., Fairchild Camera & Instrument Corp. **S. R. Viejo** has been appointed assistant general manager. **Wenzel J. Schubert**, who was general manager, has retired but will be retained as a consultant on Mr. Lasche's staff.

**Walter Kaiser** has been appointed assistant chief engineer, Thomson Electric Welder Co. Mr. Kaiser was formerly with Chrysler Corp. as welding engineer and with Progressive Welder Co. as a development engineer.

**Omer W. Nichols** has been appointed project engineer and **Karl G. Niskanen** has been named assistant process engineer for Kennametal, Inc. Mr. Nichols was formerly with the Transformer & Generator Div., Westinghouse Electric Corp., and Mr. Niskanen was with Pratt & Whitney Aircraft Div., United Aircraft Corp.

**E. Leslie Priestman** is director of industrial engineering for Atlas Plywood Corp. Mr. Priestman has been chief industrial engineer, Towle Manufacturing Co., for the past ten years.

**Leonard F. Yntema**, director of research at Fansteel Metallurgical

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# POWDER METAL PRESSES

***FROM 10 TONS TO 500 TONS • DIE FILLS UP TO 15"***

***HYDRAULIC OR MECHANICAL MODELS***

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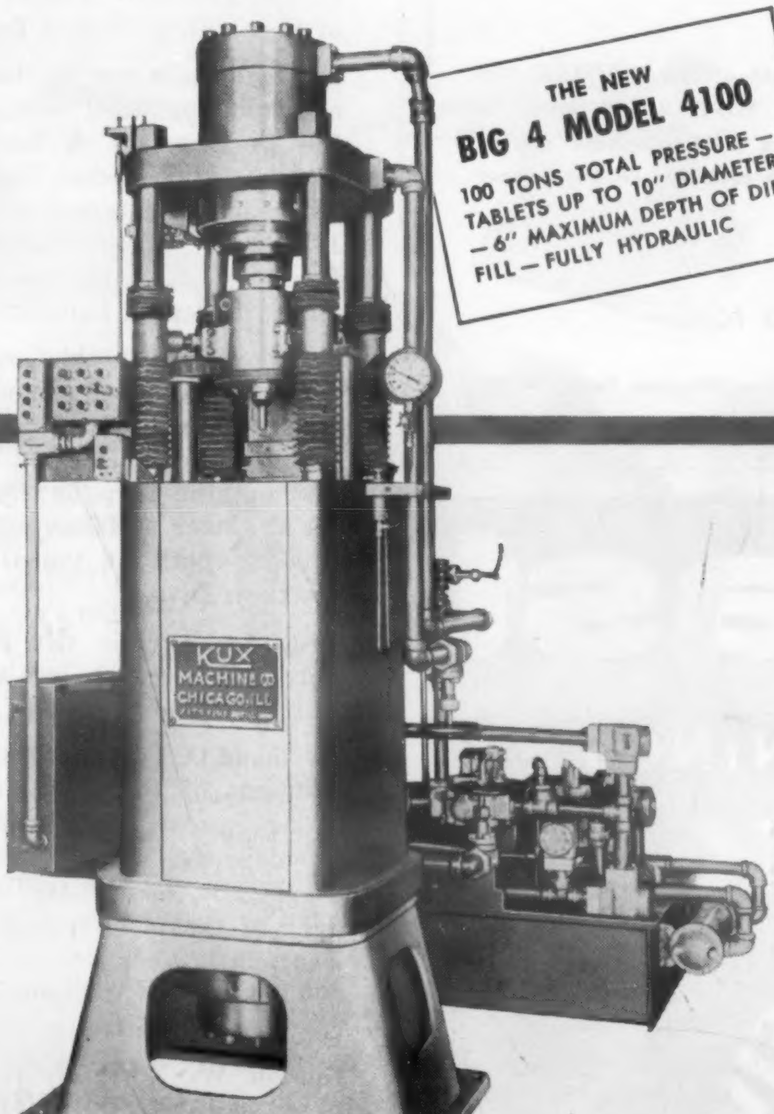
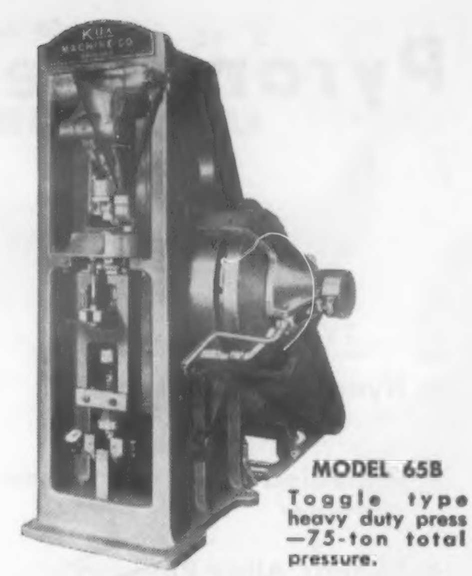



**THE NEW BIG 4 MODEL 4100**

**100 TONS TOTAL PRESSURE — TABLETS UP TO 10" DIAMETER — 6" MAXIMUM DEPTH OF DIE FILL — FULLY HYDRAULIC**

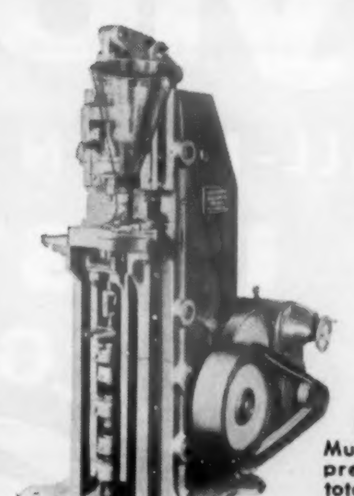


**MODEL 65B**

**Toggle type heavy duty press —75-ton total pressure.**

**BIG 4 MODEL 450B**

**Mechanical press 50 tons total pressure.**



**MODEL 64**

**Multiple motion press — 30 tons total pressure.**

- **Fully Hydraulic**—applies pressure to tablet with both upper and lower punches. Lower punch ejects tablet with full forming pressure.
- **Completely Automatic**—pushbuttons operate machine continuously or through a single cycle with an automatic stop position.
- **Accurate Dimensional Thickness of Tablets**—upper and lower punches come to a positive mechanical stop position, holding thickness of each tablet.
- **Always True Density**—upper and lower punches can be adjusted to come to a hydraulic pressure stop position, applying exact pressure on the tablet to give true density regardless of variation in die fill.
- **Perfect Punch and Die Alignment**—take-up bushings on tie bars permit punches and die to be held in perfect alignment.
- **Simple Adjustment and Locking**—of die fill and upper and lower pressure strokes.
- **Quick, Easy Tool Changeovers**—because punches, die and core rod mountings are readily accessible.
- **Accurate Die Filling**—with hydraulically operated shuttle-type shoe. Controlled speed of movement.

# KUX

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**For more information, turn to Reader Service Card, Circle No. 523**

## news of ENGINEERS

Corp., has been appointed by the National Advisory Committee for Aeronautics as a member of the Subcommittee on Power Plant Materials.

**Ira L. Kasindorf** is now chief development engineer for the Eastern Components Div., Servomechanisms, Inc. He was formerly a staff engineer.

**Leo H. Marsh** is manager of the Manufacturing Engineering Dept. of the Des Moines Implement Plant, Tractor & Implement Div., Ford Motor Co. **Ernest W. Kuzma** is manager of the Quality Control Dept.

**L. M. Diran** is now in charge of cast constructional steel developments for the Development & Research Div., International Nickel Co., Inc. Mr. Diran joined International Nickel in 1954 as a research metallurgist in the Ferrous Casting Section of the company's Research Laboratory.

**Herbert Wolf** is chief engineer, research and development, for the Worthington Corp. Air Conditioning & Refrigeration Div. Mr. Wolf joined Worthington Corp. in 1950 as a product engineer and has served in this capacity both at the Holyoke and Harrison Divs.

**Fritz J. Nagel** is vice president of Polymer Processes, Inc., a subsidiary of the Polymer Corp.

**Raymond O. Voss** has been appointed manager of the newly created Ceramic Research Dept., Research & Development Div., Corning Glass Works. **Dr. Jean P. Williams** is manager of the new Technical Services Dept. Mr. Voss joined Corning in 1942 and Dr. Williams joined the company in 1950.

**Gordon W. Reed**, chairman of the board of Texas Gulf Producing Co., has been elected to the board of directors of Climax Molybdenum Co.

**Eli Hartz** has been made manager of the vacuum forming plant of the Panelyte Div., St. Regis Paper Co.

**George Krauss, Jr.**, has been assigned to the Metallurgical Laboratory, Technical Div., Superior Tube Co., and **Rodney G. Utter**, to the company's Mechanical Development Div.

**Dr. Lauchlin M. Currie**, formerly vice-president of National Carbon Co., has been appointed a vice-president of Union Carbide Nuclear Co.

*(News of Companies on p. 264)*

## news of | COMPANIES

**Allegheny Ludlum Steel Corp.** is installing a 2000-ton forging press at its Dunkirk Works in New York for use in the hot working of high alloy tool steels and other high alloy and special metal products.

**American Steel & Wire Div.,** U. S. Steel Corp., has begun construction of a wire fabric mill that will add up to 40,000 tons of finishing capacity annually to its Cuyahoga Works. The new plant being built in Cleveland will cover almost 53,000 sq ft.

**Bridgeport Brass Co.** and **Hunter Douglas Aluminum Corp.** have combined facilities through an exchange of Hunter Douglas for Bridgeport Brass common stock. Hunter Douglas operates two plants in Riverside, Calif., and another in Flemington, N. J., and does an annual volume of more than $25 million. Bridgeport Brass Co. operates seven plants with headquarters in Bridgeport, Conn., and does an annual volume of about $150 million.

**James B. Clow & Sons, Inc.,** which has announced a $5 million expansion program, plans to build the first cast iron pipe plant in the Chicago area. The plant will have a producing capacity of 80,000 tons of pipe a year for use primarily in municipal water and gas distribution systems.

**Corning Glass Works** has established two departments in its Research & Development Div. The Ceramic Research Dept. will concentrate on the development of new ceramic materials. Primary responsibility of the Technical Services Dept. will be analysis and interpretation of the physical and chemical characteristics of glass and its ingredients.

**Dow Chemical Co.** has announced a planned expansion of 30 million lb per year in ethylene oxide production capacity at its Texas Div. in Freeport.

The new **du Pont** isocyanates plant is now in production. Located at the Chambers Works, Deepwater Point, N. J., the plant is geared to manufacture 25 million lb a year.

**Orangeburg Manufacturing Co., Inc.** has commenced work on a plastics pipe plant next to its Orangeburg, N. Y., plant. Completion is scheduled for July 1956.

**Palnut Co.,** producer of lock nuts and fasteners, has moved to its new plant on Glen Rd., Mountainside, N. J.

*(More News on p. 266)*

## news of | COMPANIES

**Panelyte Div., St. Regis Paper Co.,** is opening a thermoplastics laboratory at Richmond, Ind., to complement its injection molding and vacuum forming facilities.

**Reeves Instrument Co.,** a subsidiary of Dynamics Corp. of America, has taken over a $5 million plant and has added facilities at Roosevelt Field, Mineola, N. Y. These additions will increase plant space more than 30%.

**Reynolds Metals Co.** plans a $43 million expansion that will increase production of its alumina plant near Corpus Christi, Tex., more than 50% and also enlarge facilities of the aluminum sheet rolling mill at Sheffield, Ala.

**Reynolds Philippine Corp.** recently dedicated a $3 million plant near Manila, P. I. Plant has 55,000 sq ft of floor space and an annual production capacity of 25 million lb of aluminum sheet and foil.

**Rheem Manufacturing Co.** and **Richmond Radiator Co.** have merged. The merger calls for exchange of four shares of Richmond common stock for one of Rheem. Richmond has four plants in the United States. Rheem operates 16 plants in this country and 17 abroad.

**Standard Products Co.** will expand its West Coast Div. through immediate construction of a 50,000 sq ft plant at Fullerton, Calif.

**Techalloy Co., Inc.,** has completed and put into operation a 10,000 sq ft addition that cost $250,000 equipped.

## news of | SOCIETIES

**The American Society of Heating and Air-Conditioning Engineers** met in Cincinnati January 23 to 25 with an attendance of about 850 for the 62nd annual meeting. John W. James, vice president of research, McDonnell & Miller, Inc., was installed as president of the Society. He succeeded retiring president, John E. Haines, vice president, Commercial Div., Minneapolis-Honeywell Regulator Co. Other officers installed were Peter B. Gordon, first vice president; Elmer R. Queer, second vice president; Ralph A. Sherman, treasurer.

The **Galvanizers Committee,** which is sponsored by the **American Zinc In-**

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## news of | SOCIETIES

stitute, will hold its 34th meeting on April 23 and 24 at the Hotel Statler in St. Louis. C. K. Lytle, Tennessee Coal & Iron Div., U. S. Steel Corp., is chairman. E. P. Beachum, Bethlehem Steel Corp., and R. J. Stoker, U. S. Steel Corp., head the program subcommittee. This meeting takes place at the same time as the annual meeting of the American Zinc Institute.

**The Pressure Sensitive Tape Council** has announced the election of C. I. Lee as president. Mr. Lee is president of Hampton Manufacturing Co. B. W. Lueck of Minnesota Mining and Manufacturing Co. was elected vice president, and Richard Breeden is executive secretary.

**Small Lot Metal Stamping Institute** recently elected E. J. Skramstad, Federal Tool & Mfg. Co., as president. He succeeded M. E. Lorenz, H. P. L. Mfg. Co. Mr. Lorenz and Stanley Wocknik, Short Run Stamping Co., were elected directors. Richard Boker, V. A. Boker & Sons, was re-elected vice president and G. C. Wick, W. L. S. Stamping Co., was re-elected secretary-treasurer.

**The Ultrasonic Manufacturers' Assn.** has been formed with W. C. Potthoff as president. Mr. Potthoff is vice president, Aeroprojects, Inc. Stanley R. Rich, technical director and vice president, General Ultrasonics Co., is vice president. Norman Branson, president, Branson Instruments, Inc., is secretary and Jack Welch, general manager, Machine Tool Div., Sheffield Corp., is treasurer.

**Stevens Institute of Technology** recently presented the Powder Metallurgy Achievement Award to Dr. Henry H. Hausner. He is general manager of the Nuclear Engineering Div., Penn-Texas Corp. By applying the techniques of powdered metallurgy in the field of atomic energy, Dr. Hausner is credited with speeding the use of nuclear power for peaceful purposes.

*(Meetings & Expositions on p. 270)*

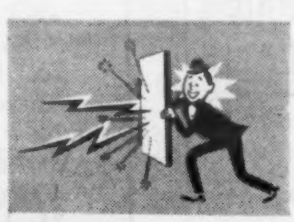
Plan to attend the
DESIGN ENGINEERING SHOW
Philadelphia Convention Hall
May 14-17.

# a combination . . . for game!

## *laminated plastics* . . . a combination of properties for trouble-shy designers

**When a man goes a-hunting for a material for a specific application, he wants one that satisfies his own combination of property requirements . . . *and is easy to machine.* Synthane laminated plastic is just the material—*plenty* of good mechanical, electrical, electronic and chemical properties . . . combined with excellent machining and fabricating characteristics.**

**Synthane terminal insulators** must meet high property and machining standards. They must have high dielectric strength in a machinable insulator, good moisture resistance, excellent arc resistance, good heat resistance and mechanical strength. This insulator and similar parts can be fabricated at the Synthane plant with no waste, no problems to the purchaser.



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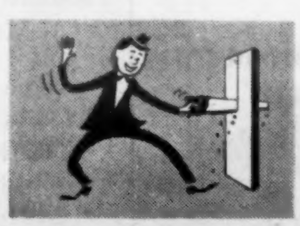
HIGH STRENGTH-TO-WEIGHT RATIO



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## Meetings and Expositions

METAL POWDER ASSN., annual meeting and metal powder show. Cleveland. Apr. 10-12, 1956.

MALLEABLE FOUNDERS' SOCIETY, annual market development conference. Chicago. Apr. 12-13, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Gas Turbine Power Div. conference. Washington, D. C. Apr. 16-17, 1956.

AMERICAN CERAMIC SOCIETY. New York. Apr. 22-26, 1956.

AMERICAN ZINC INSTITUTE, annual meeting. St. Louis. Apr. 23-24, 1956.

SOCIETY OF THE PLASTICS INDUSTRY, Midwest plastics conference. French Lick, Ind. Apr. 25-27, 1956.

ELECTROCHEMICAL SOCIETY, spring meeting. San Francisco. Apr. 29-May 3, 1956.

NON-FERROUS FOUNDERS' SOCIETY, annual meeting. Atlantic City. May 3, 1956.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention and exhibition. Atlantic City. May 3-9, 1956.

AMERICAN WELDING SOCIETY, national spring meeting and 4th welding and allied industry exposition. Buffalo, N. Y. May 8-11, 1956.

DESIGN ENGINEERING SHOW, exposition and conference. Philadelphia. May 14-17, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting. Atlantic City. June 3-8, 1956.

MALLEABLE FOUNDERS' SOCIETY, general meeting. Hot Springs, Va. June 11-12, 1956.

SOCIETY OF THE PLASTICS INDUSTRY, seventh national plastics exposition. New York. June 11-15, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Applied Mechanics Div. conference. Urbana, Ill. June 14-16, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. Cleveland. June 17-21, 1956.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City. June 18-22, 1956.

ALLOY CASTING INSTITUTE, annual meeting. Hot Springs, Va. June 24-26, 1956.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer and Pacific general meeting. San Francisco. June 25-29, 1956.

# MATERIALS ENGINEERING NEWS

*(Continued from p. 11)*

The Maytag Co.

**Problems in Miniaturization** — William C. Schmidt, Merrimack Valley Laboratory, Bell Telephone Laboratories, Inc.

Thursday, May 17

**Recognition and Reward for Invention**—W. A. Steiger, Patent Dept., Westinghouse Electric Corp.

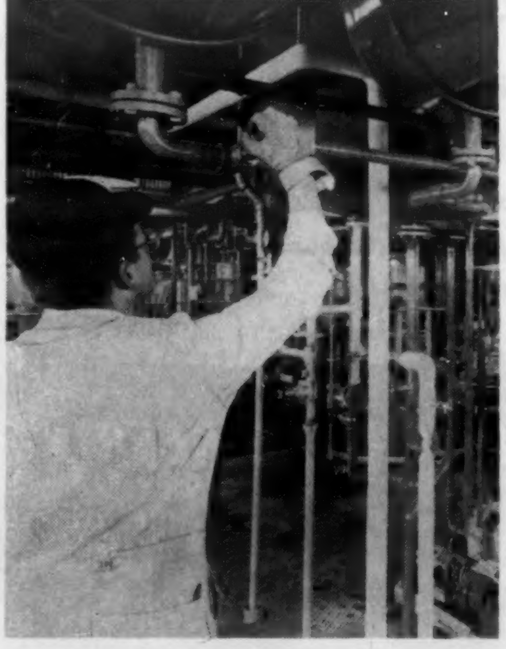
**Rights of the Employees' Inventions** — George V. Woodling, Patent Attorney.

## More Silicones at Lower Prices

New plant facilities of Dow Corning Corp. will more than double its previous methyl siloxane capacity.

Completion of the $16 million plant expansion program was marked by a 7½% reduction in price of dimethyl silicone fluids and emulsions. New prices of dimethyl silicone fluids and mold lubricants are less than half of their original prices when first produced. New price of DC 200 Fluid is $3.14 per lb and silicone mold release emulsions now cost $1.26 per lb.

*(More News on p. 274)*



***One stage** of a silicone manufacturing plant.*

# MATERIALS ENGINEERING NEWS

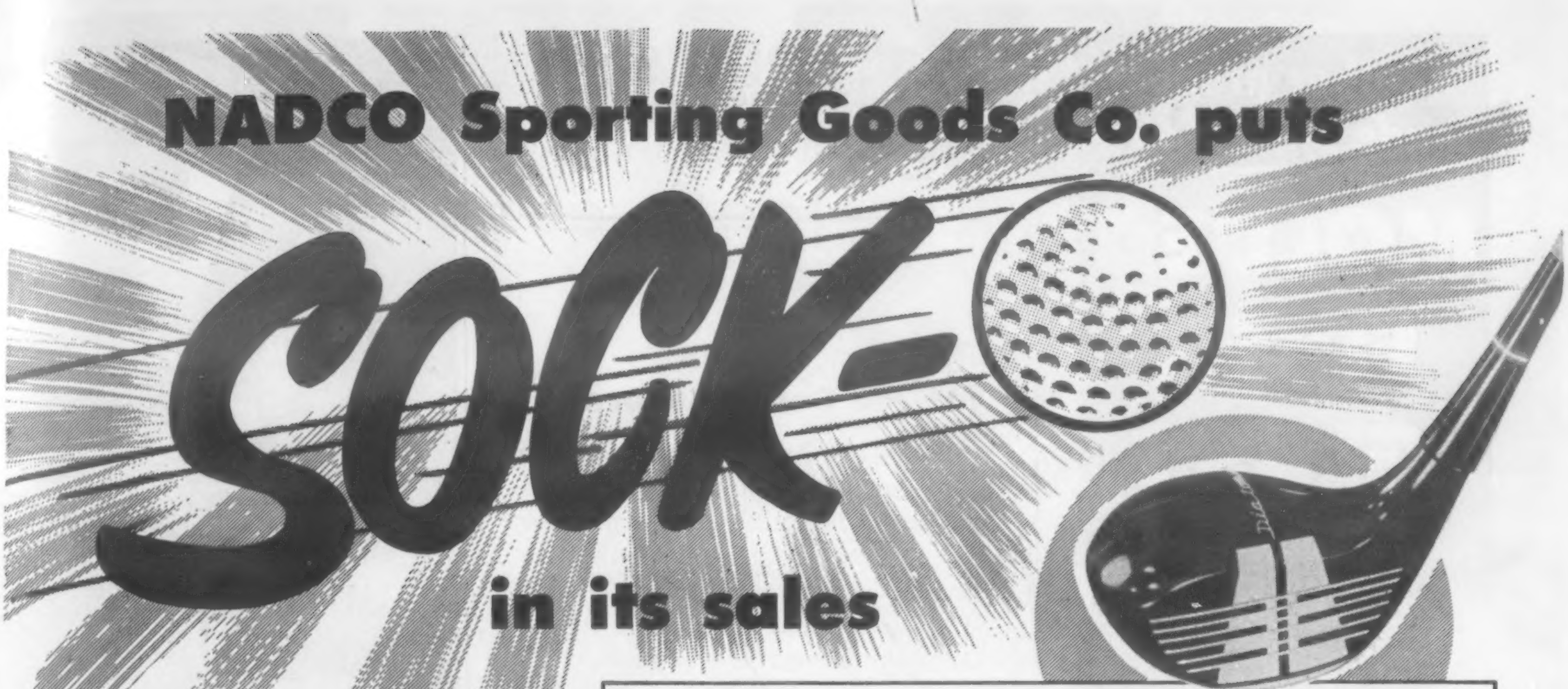
## Acrylic Paint Sales Double in Year

Acrylic paint sales doubled in volume last year, with a similar increase in the number of companies producing acrylic paints, according to Gerould Allyn of Rohm & Haas Co. Over 300 companies are now producing water paints based on acrylic emulsions.

Modern water paints are only eight years old, Allyn pointed out, but annual production has already passed the 50 million gallon mark. Figures on total sales achieved by each of the latex types (butadiene styrene, polyvinyl acetate and acrylic) have not been released by the producers. It is known, however, that production of all water-vehicle paints has been increasing at the rate of at least five million gallons a year for the past five years.

*(More News on p. 276)*

**Purity requirements** in this chamber of M. W. Kellogg Co.'s new synthetic rubber plant in Jersey City, N.J., are so critical that technicians working in the area must wear coveralls and footgear approaching a surgeon's dress.




Nadco Sporting Goods Co., Chicago, Ill., has specified Cycolac for the heads of a new line of top-quality golf clubs known as Nadco Diatomic. The new plastic heads are designed to overcome many of the problems associated with even the finest wooden club heads. In addition to their high impact properties, the Cycolac heads, unlike wooden club heads, will not absorb moisture and therefore will not change in weight or dimensions.

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**THE *New* HIGH-IMPACT THERMOPLASTIC RESIN**

CYCOLAC is a single uniform resin which is permanently thermoplastic, permitting fast molding, calendering and extruding, and re-use of trim and cutting scrap. Also economical to form from press-polished sheets by vacuum, air-pressure, or mechanical methods over inexpensive molds of wood, plaster, aluminum, etc.

CYCOLAC is free from nerve or shrinkage; with a high in impact-resistance and heat-distortion temperature, plus a low brittle point. Resistant to many oils, solvents and corrosive chemicals. Very light — Sp. Gr. 1.01.

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For more information, turn to Reader Service Card, Circle No. 538

# MATERIALS ENGINEERING NEWS

## Plastics Blades for Jet Compressors

Over 100 hr of operating time have been accumulated on an experimental engine using plastics compressor blades. According to Robert B. Johnson, Jr., of General Electric's Aircraft Gas Turbine Div., the compressor blades were used in five stages of a J47 compressor rotor.

Composed of glass-reinforced phenolic resin, the plastics blades showed very good erosion resistance and excellent stress characteristics, and appeared to be capable of operating continuously between 450 and 500 F. These observations agree substantially with previous results reported by Curtiss-Wright and Thompson Products *(see M&M, Mar 1955, p 12)*.

"While the blades operated successfully in the J47, the 500 degree temperature limitation precludes their use in advanced engines where operating temperatures are higher," Johnson said. "However, if resins are developed which can withstand the higher temperatures, we feel that plastics blades may be useful in the future."

The plastics blades weigh about 6 lb less per compressor stage than conventional steel ones, and manufacturing costs appear to be only 25% of forged blade expense.

## Boron Price Is Cut

American Potash & Chemical Corp. recently announced substantial price reductions in quantity lots of elemental boron ranging up to a 35% decrease in quantities of 100 lb or more. New price is $13 per pound for large quantities. Elemental boron has been available in commercial quantities only for the past few years.

*(More News on p. 278)*


# Fastenings that defy corrosion

Harper stainless steel bolts, screws, nuts, washers and rivets are the answer to many fastening problems where corrosion is a factor.

No additional cost for these Harper advantages of longer life and improved appearance for the equipment you manufacture. See your Harper Branch or Distributor or write for Catalog 26.

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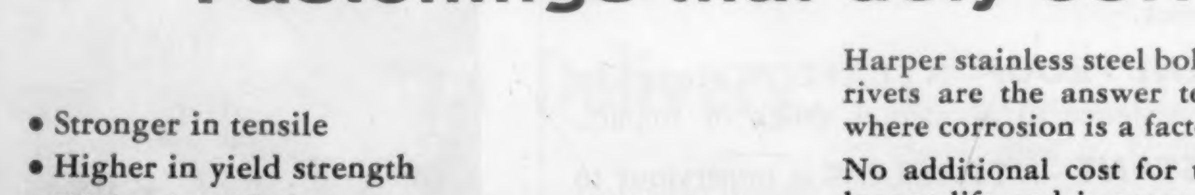

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# MATERIALS ENGINEERING NEWS

## Acrylic Products Marked Down

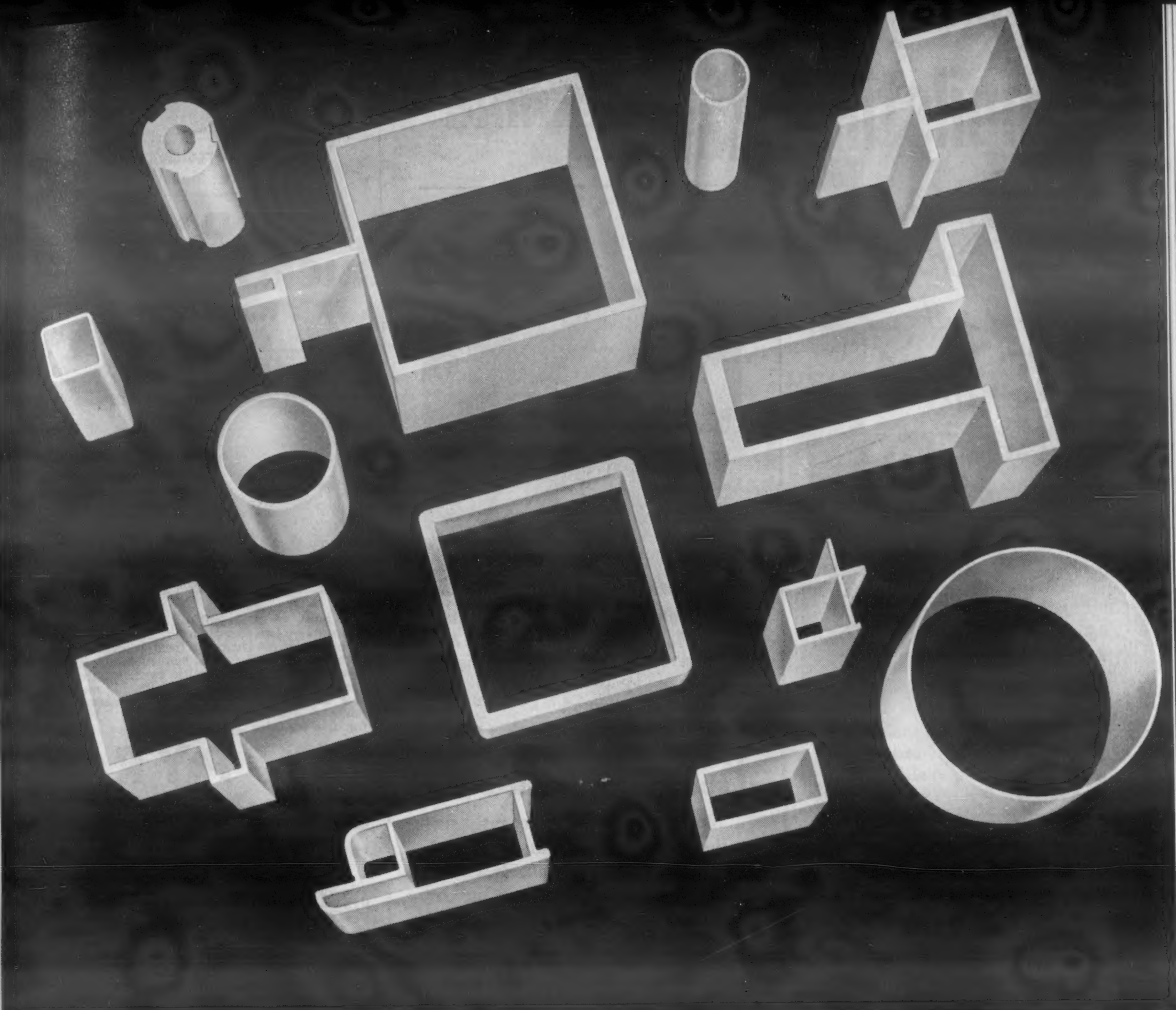
With the aim of entering markets where price was formerly a barrier, Rohm & Haas Co. has announced reductions ranging up to 9½% in acrylic products. Products affected are Plexiglas sheet, Plexiglas molding powders and methyl methacrylate monomer, an intermediate in the manufacture of Plexiglas and related products.

Standard grades of injection molding powders were reduced 4¢ per lb in the large quantity brackets. Delivered truckload prices are now 55¢ for colorless and 59¢ for colors.

Sheet price reductions apply to Plexiglas R, II and IA in thicknesses of 0.10 in. and over. Reductions range from to about 9½%.

*(More News on p. 280)*

**Pattern of digits** and letters only .012 in. high was placed in nickel .0001 in. thick by W. & L. E. Gurley, manufacturers of binary code disks for electronic industries. Gurley electroformed the characters in the matrix by nickel plating on a beryllium copper base. After the image was formed in the nickel, the beryllium copper was removed from behind the characters by electro-etching.



# MATERIALS ENGINEERING NEWS

***Stud welding** with template fixture. In background, a longitudinal butt joint in a compressor housing is being made by semi-automatic submerged arc welding.*

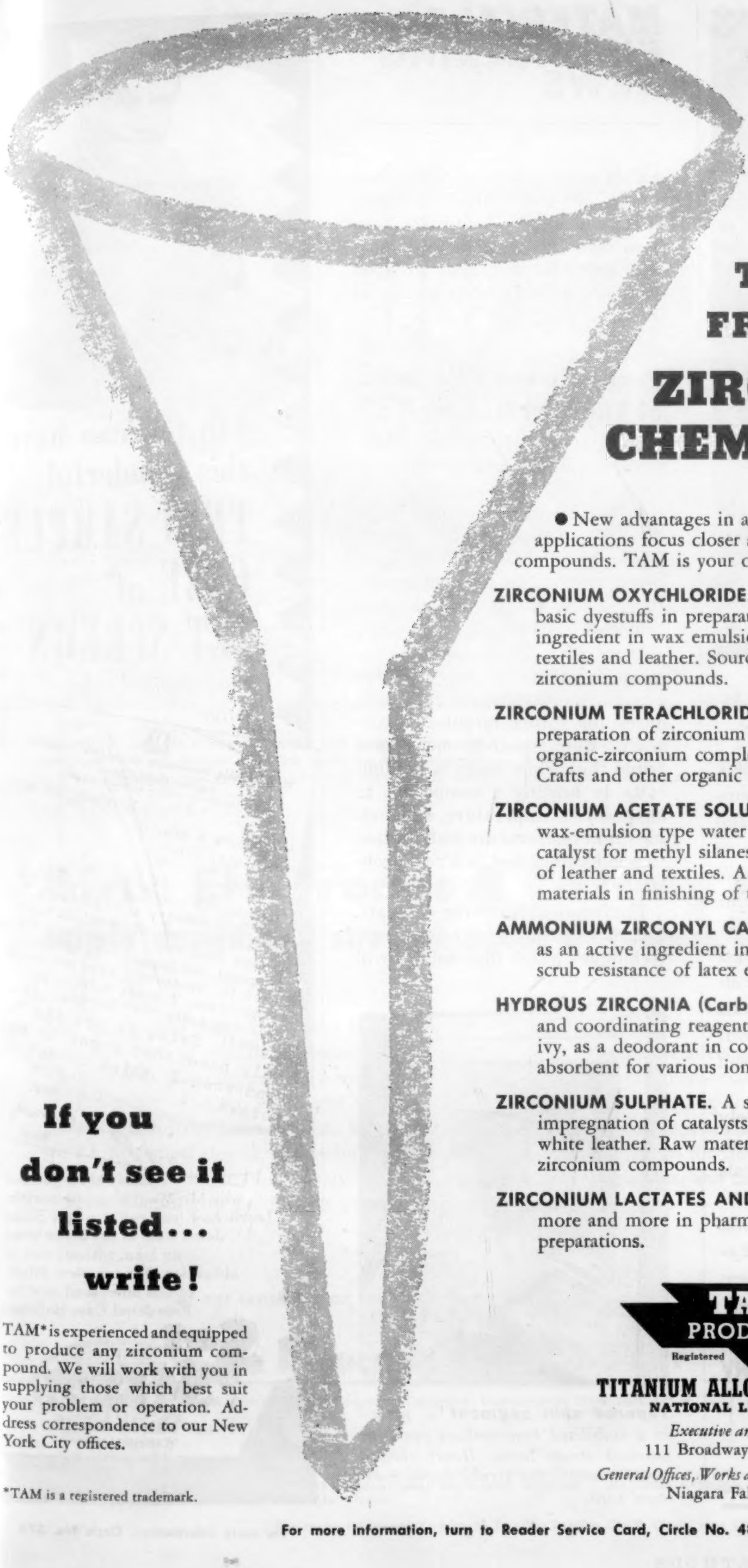
## Welding Research Laboratory Opened

Worthington Corp. recently unveiled its new welding research laboratory at Harrison, N.J. Designed to provide the company with increased service in the application of advance welding techniques, the laboratory has more than 5000 sq ft of shop space.

The functions of the new laboratory will include designing and building models or full scale test weldments, developing new welding techniques, and testing commercial materials and equipment. Laboratory facilities are available for fabricating and welding structures up to 10 tons, and an automatic manipulator and tilting floor is located in a nearby shop. The table for this machine is 18x33 ft and weighs 65,000 tons.

## ASTM Committee on Electronic Materials

Recognizing the growing importance of materials for electronic applications, the American Society for Testing Materials has set up a new Committee on Electronic Materials. It is the first



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**ZIRCONIUM OXYCHLORIDE.** A precipitant for acid and basic dyestuffs in preparation of lakes and toners. Active ingredient in wax emulsion type water repellents for textiles and leather. Source material for other zirconium compounds.

**ZIRCONIUM TETRACHLORIDE.** Raw material for preparation of zirconium metal, zirconium alloys, and organic-zirconium complexes. Catalyst for Friedel-Crafts and other organic syntheses.

**ZIRCONIUM ACETATE SOLUTION.** Active ingredient in better wax-emulsion type water repellents for textiles. A catalyst for methyl silanes in silicone repellent treatments of leather and textiles. A precipitant for many proteinic materials in finishing of textiles, leather, etc.

**AMMONIUM ZIRCONYL CARBONATE SOLUTION.** Used as an active ingredient in basic water repellents. Improves scrub resistance of latex emulsion paints.

**HYDROUS ZIRCONIA (Carbonated).** A strong chelating and coordinating reagent. Useful in treatment of poison ivy, as a deodorant in cosmetic creams, and as an absorbent for various ions.

**ZIRCONIUM SULPHATE.** A source for zirconia for the impregnation of catalysts. As a tanning agent...processing white leather. Raw material for preparation of organic-zirconium compounds.

**ZIRCONIUM LACTATES AND GLYCOLATES.** Being used more and more in pharmaceuticals and personal deodorant preparations.

## If you don't see it listed... write!

TAM* is experienced and equipped to produce any zirconium compound. We will work with you in supplying those which best suit your problem or operation. Address correspondence to our New York City offices.

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# MATERIALS ENGINEERING NEWS

ASTM committee to be established on an end-use basis. Previously all committees on materials have been made responsible for a specific group of materials grouped according to their composition and form.

## Probe Stress Effects of Thermal Barrier

High speed missiles or rockets can leave an earth temperature of 70 F and within seconds achieve skin temperatures of 300 F or more depending on their speed. While metallurgical effects of a given temperature are well known, these stress effects of flight-friction heat are not.

Developing data on thermo-stress problems is essential for evolving workable design procedures for future missiles or aircraft. But research men have found that while there is no difficulty in heating a component to any desired temperature, duplicating flight temperature distribution in a laboratory test is a real problem.

Engineers at Northrop Aircraft, Inc., have come up with some new techniques which they believe will

***Tapered skin segment** is placed in a stabilized temperature oven for thermal stress tests. Heart shaped tubes insulate the strain gages from oven heat.*

The Harbormaster, is a king-size power unit designed for rough use aboard barges, dredges and work boats. An Airco Oxygraph is a key production tool used to quickly and economically flame cut over 25 of its component parts from heavy steel. Airco electrodes—the Easyarc 12—are depended upon for the utmost in strength and welding speed.

# Airco Electrodes & Cutting Machines

## satisfy design and strength needs for unique outboard engine

The Mathewson Machine Works Inc., have been manufacturers of marine equipment since 1885. They find in building the Harbormaster that the extensive use of Airco electrodes, cutting equipment and industrial gases combine to provide them with the greatest degree of production flexibility and the widest margin of economy.

From planning to production you can rely on assistance—and completely unbiased recommendations—from Airco Technical men. For Airco is the leading supplier—manufacturer of all kinds and every type of welding and flame cutting processes, their controls, supplies and accessories.

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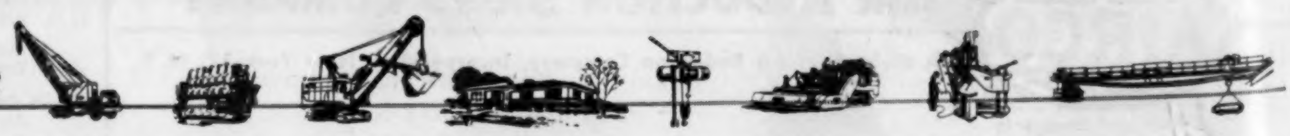


P&H welding equipment is manufactured and sold in Canada by REGENT EQUIPMENT MANUFACTURING COMPANY LTD., 455 King Street West • Toronto, Ontario, Canada

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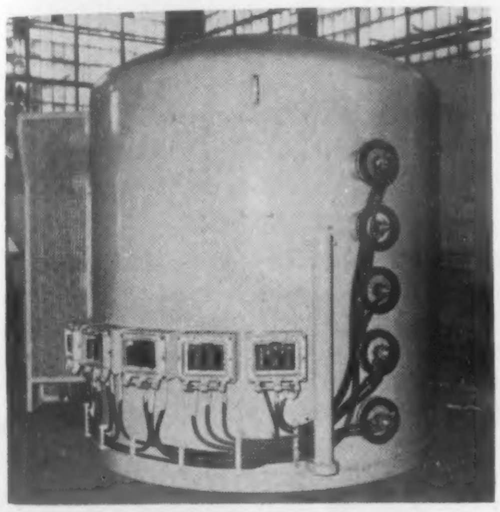
provide some of the answers. They have developed new types of resistance heat ovens for close temperature control and have devised usages of infra-red quartz thermal lights. One type of oven incorporates means for inducing temperature differences in a specimen for extended periods of time.

In one application, structures research engineers found that an experimental skin panel buckled because of heat-induced stresses. The condition was corrected through use of a honeycomb core which stabilized the skins. The new construction is cheaper on a volume basis than the original method, it is lighter, and flight efficiency has been considerably increased.

Other experiments with infra-red developed enough heat to melt metals within 5 sec of the time the heat is applied.



**Electric resistor** furnace is used to convert liquid titanium tetrachloride to sponge titanium by reduction with magnesium.
*(Westinghouse Electric Corp.)*

Plan to attend the
DESIGN ENGINEERING SHOW
Philadelphia Convention Hall
May 14-17

## LETTERS TO THE EDITOR

*Continued from p. 14*

as from a practical standpoint, no better method of commercial protection has as yet been devised. Therefore, if and when you publish a subsequent Manual on "Finishes for Metal Products", we sincerely trust that you will not only give adequate space to hot dip galvanizing but extoll its advantages as the best rust-resisting coating available.

STUART J. SWENSSON
Secretary
American Hot Dip Galvanizers Assn., Inc.
Pittsburgh, Pa.

### Plastics properties

To the Editor:

We are interested in purchasing a chart or book of weights and measures on plastics. The chart or book must have the following information:

- Amount of feet per pound of tubes
- Wall thickness
- I. D. and O. D. Tubing
- Graduated scale
- Round rod—flat sheets, etc.
- Sheets (Block & Mandrel), rods and tubes

P. CLAUS
Mastercraft Plastics Co.
Jamaica, N. Y.

*We know of no chart or book which includes the information requested. Work is being done on standards and specifications for plastic pipe and tubing, but standards are yet to be established. The best recourse is to contact suppliers directly.*

### Correction

To the Editor:

We have at hand your Manual 124, which appeared in your issue February 1956. Section 9, Upset Forgings, has been carefully reviewed by our forging engineering staff. Exception has been taken to three statements in this section:

1. "Upset forgings are made from round bars of metal, and the parts possible are limited to cylindrical shapes." A considerable volume of parts are economically produced by upset, which are not cylindrical, not symmetrical, not produced from round stock. Squares, oblong sections, H-sections, angles, in fact any section that can be rolled can be operated on by upsetting.

2. "The length of bar to be upset cannot be greater than three times its diameter, etc." This is the limiting rule for single operation. Multiple operations permit gathering of many times bar diameter.

3. "The finish in upset forgings is likely to be less satisfactory than with other methods." The finish resulting from any hot forging process is directly related to the attention given to heating and cleaning the stock. Modern induction heating practice permits upsetting with surface finishes often better than that of the parent bar stock.

MERRITT J. HOFFMAN
Methods Engineer
The Bingham-Herbrand Corp.
Fremont, Ohio